Herbaugh, Melinda

From:	Karen Walter <KWalter@muckleshoot.nsn.us>
Sent:	Monday, May 15, 2017 3:09 PM
To:	Johnson, Joshua R (DCI); PRC
Subject:	3018093, Unit Lot Subdivision
Attachments:	Mapes Creek report_WATrout 2002.pdf; Stream Habitat Report Puget Creek 022114 Final.pdf

Mr. Johnson,

We have reviewed the proposed subdivision at 9661 51st Avenue South and offer the following comments in the interest of protecting and restoring the Tribe's treaty-fisheries resources:

1. The stream that is located on this property it Mapes Creek. It should be noted that drains into Lake Washington and given its size, it is likely a potential-fish bearing water, if not for the existing human-created fish passage barriers on it (see attached report from WA Trout). The City's 2007 State of the Watershed Report notes that stickleback were found in Mapes Creek. The Critical Areas Study for the project (dated October 18, 2010) does not sufficiently assess the portion of stream onsite to see if it meets the physical criteria from WAC 222-16-031 for presumed fish use. Rather, on page 8, it states that "*this onside drainage corridor appeared to meet the criteria for designation as a WDNR Type 4 water within the project site*". Please note that WDNR has specific requirements and methods to determine water typing. It does not appear that these methods were followed nor the data provided. The stream should be reevaluated to see if it meets the physical criteria for presumed fish habitat using WAC 222-16-031 and WA Forest Practices Board Manual 13 by a qualified fisheries biologist experienced making these determinations. An example of a complete report following these methods is attached.

2. With the stream typing information documented as described, the project should be re-evaluated for potential impacts, including compliance with stream buffer requirements and potential impacts to fish habitat from stormwater discharges.

3. At a minimum, the project should be required to remove all existing dams and stream obstructions to allow for fish habitat functions to be restored at least for downstream areas should the immediate stream section meet Type 4 /5 (or Type N) waters per the WAC.

We appreciate the opportunity to review this proposal and look forward to additional information to address these concerns. We may have further comments subsequently. Please let me know if you have any questions.

Thank you,
Karen Walter
Watersheds and Land Use Team Leader

Muckleshoot Indian Tribe Fisheries Division
Habitat Program
Phillip Starr Building
39015-A 172nd Ave SE
Auburn, WA 98092

WASHINGTON TROUT

Assessment of Mapes Creek Habitat, Fish Passage, and Fish Species Composition and Distribution

By

Washington Trout

For

Seattle Public Utilities

December 31, 2002

Background

This document is a report of a watershed assessment survey conducted in the Mapes Creek watershed during fall 2002. The purpose of this report is to synthesize and present the findings of a stream habitat survey, a culvert/fish passage survey, and a fish species composition and distribution survey to assist Seattle Public Utilities in their efforts to determine overall salmonid habitat quantity, quality, and accessibility for Mapes Creek.

The Mapes Creek watershed begins in a forested green space adjacent to the Kubota Gardens, a City of Seattle park. The creek's headwaters consist of a series of wetlands and seeps that originate in two valleys within this open space. Mapes Creek then flows through the Kubota Gardens proper and is incorporated into the park's landscaped pond system. Downstream of the park, Mapes Creek flows into a residential neighborhood before it is directed into a culvert which runs under a mixed urban use area and into Lake Washington.

Introduction

Mapes Creek is a south to north flowing, second order stream that drains a predominantly urban basin in the Rainier Beach neighborhood of Southeast Seattle. The headwaters of Mapes Creek are riverine wetlands that form where groundwater springs seep into an intermittent channel (Photo 1). The two upper (East and West) forks of Mapes Creek are heavily forested with large riparian areas consisting of mostly deciduous trees (Photos 1, 2, and 3). On both forks lateral wetlands adjacent to the creek significantly contribute to the base flow of the upper stream. Downstream from the confluence of the East and West forks, the first major tributary flows into Mapes Creek from a right bank culvert that connects directly to the outflow of the Kubota Gardens Duck Pond (Photo 4). Shortly downstream from this confluence Mapes Creek is incorporated into a chain of artificial ponds and channels in the Kubota Gardens (Photos 5 and 6). A second right bank tributary contributes to the flow of Mapes Creek where a natural spring feeds into two adjacent ponds (Koi Ponds 1 and 2, see Map 1) and eventually into the mainstem of Mapes Creek at the lowest pond in the chain (Photos 7 and 8). It is also at this lowest pond that an artificial left bank tributary is maintained by the pumping of water from the pond to the top of a waterfall. City of Seattle maps show this as an eastward flowing tributary to Mapes Creek, but as it does not actually contribute any flow to the system it is not considered a tributary for the purposes of this report.

At the outlet of the chain of ponds Mapes Creek flows into a straightened channel for the remaining length of the park. This channelized section of creek is lined with Blackberry bushes and there is little riparian cover to shade the creek. Downstream from the Kubota Gardens, Mapes Creek flows into a series of large, shallow sediment pools created by four concrete dams or weirs. In each of these sediment pools there is a decrease in flow and the channel broadens to the width of the concrete weirs (Photos 9, 10, and 11). Three of the four weirs are completely filled with fine sediments and are no longer storing significant amounts of water. In this reach of the creek there is a mix of vegetation types in the riparian zone with mature forest dominating. The outlets of three of the four weirs are no longer functioning and water is seeping under or around the weirs. Downstream of the weirs the creek goes into a culvert beneath Renton Avenue.

Downstream of Renton Avenue, Mapes Creek enters a steep-sided forested ravine with homogenous riffle habitats (Photos 12 and 13). The upper 200 ft of this ravine was not included in the survey because a landowner denied permission to access their property, but a 60 ft section of stream just above the Roxbury culvert was accessible. Downstream from the Roxbury Street culvert, the stream is also confined in a steep-sided forested ravine dominated by simplified riffle habitats and one large sediment pool (Photo 14). At the downstream end of this reach Mapes Creek enters the Sturtevant/Rainier culvert and is piped underground until it flows into Lake Washington (Photos 15 and 16).

Methodology

Mapes Creek's biological and physical characteristics were surveyed to determine overall salmonid habitat quantity, quality, and accessibility for Mapes Creek. Survey parameters including fish habitat characteristics, such as habitat unit type; spawning gravel; and large woody debris (LWD) metrics, as well as riparian corridor characteristics, fish species composition and distribution, and the presence of potential fish passage barriers. The spatial scale of the surveys extended from the Sturtevant/Rainier culvert inlet upstream to the headwaters of both the east and west branch tributaries with exception of the reach where access was denied extending 60 ft upstream of the Roxbury culvert inlet to the Renton Avenue culvert inlet.

Reach Designations

A total of 8 reaches and 2 sub-reaches were designated for the surveyed portions of Mapes Creek (Map 1). These reach designations were based on criteria which included significant changes in channel characteristics like flow, gradient, valley form, and instream habitat.

Habitat Unit Surveys

A modified version of the Timber / Fish / Wildlife (TFW) habitat methods and classification system, described in the *Habitat Unit Survey Module of the TFW monitoring Program Method Manual*, was utilized to document current channel morphology and identify primary habitat type, distribution, and abundance. During a low flow period in October 2002, a total of eight separate reaches were identified and surveyed, with reference points flagged at 200 ft intervals. Bankfull widths and photographs were taken using a modified version of the TFW Reference point survey module method (Schuett-Hames et al. 1996). A Spencer tape or stadia rod was used to measure bankfull channel widths as evidenced by erosion and vegetation breaks along bank berms. In instances where only one berm existed, measurements were taken from the high water mark on the berm side across to the same elevation on the opposite bank. Bankfull depths and canopy closure estimates were not performed in this survey.

Once reference points were established, habitat surveys were conducted walking upstream from the inlet of the Sturtevant/Rainier culvert. A TFW defined habitat unit is a variation in hydraulic conditions, such as velocity and water depth. Wetted portions of the channel were placed in one of the following two primary TFW habitat unit classifications: Pool (P) or, Riffle (R), which are defined as follows:

Pools –…a section of stream channel where water is impounded within a closed topographical depression…

Riffle – …a shallow and low gradient area with surface turbulence associated with increase flow velocity over gravel or cobble beds. However, riffle classification also includes deeper areas without surface turbulence such as "glides" and "pocket water" conditions, and higher gradient/turbulence areas such as "cascades" and "rapids"… (Schuett-Hames et al. 1999)

Primary Pool habitats were required to meet the minimum size and residual depth criteria established in the TFW Habitat Module. Riffle habitat units classifications were based on depth, gradient, and velocity criteria. In our survey, cascades and glides were assigned to riffle classification units. Portions of the channel that were not visible, such as those in culverts under roads, were classified as obscured (O). TFW habitat classifications that were intended for natural functioning river systems were augmented with the following two urban primary habitat classifications found in Mapes Creek:

1) Sediment pool (SP) – broad shallow (less than 0.25 ft deep) areas that flow over a deep (greater than 2 ft deep) layer of saturated mixed silt and organic sediment, often with emergent vegetation, as found immediately upstream from dams or weirs.

2) Artificial pond (AP) – any portion of the stream or ponds incorporated into the Kubota gardens.

Habitat units were identified and documented sequentially walking upstream. Location, length, and wetted width were measured with a hip chain, Spencer tape, or stadia for all habitat units except sediment pools and artificial ponds. Dominant channel substrate type was categorized and documented using the substrate classification defined in the King County Department of Development and Environmental Services (DDES) document, *Stream Survey Report Criteria* (King County undated). Sub-habitat units within riffle or pool habitat units were measured in the same manner as primary habitat units and categorized utilizing the *Pacific Southwest Regions Habitat Typing Field Guide* (US Forest Service undated) sub-habitat unit classification scheme.

Due to the size and depth of fill in sediment pools and artificial ponds, visual measurements calibrated off the 200 ft reference points or off an extended stadia rod were utilized to measure lengths and wetted widths in sediment pools and artificial pond units. Similarly, because of limited access and depth of fill throughout sediment pools, we were unable to determine absolute maximum depth; thus, maximum depth measurements for sediment pools may exceed depth measurements documented.

Stream flow Measurements

On October 30th, stream flow measurements were collected at four locations within the watershed (Map 4), and were visually estimated at two other locations. Flow measurements were collected using either a Global Water flow meter in a stream cross-section, or timing the filling of a 5-gallon bucket. Stream cross-sections were calculated using a Spencer tape and stadia rod, with flow measurements taken at 0.2 ft intervals across the stream channel.

Substrates/Spawning Gravels

During the course of the instream habitat surveys, the location and extent of potential salmonid spawning gravels were documented. The following criteria were used to identify suitable spawning gravels: 1) gravels must be within the wetted channel; 2) gravels must be located at a suitable site within the habitat unit such as a tailout or riffle crest; 3) gravels must have a surface area of not less than 2 ft^2 for small bodied salmonids and 6 ft^2 for large bodied salmonids 4) gravels must have a dominant particle size of >8-64 mm or >64 mm-128 mm; 5) gravels must have flowing water over the site; and 6) gravels must have a depth of not less than 6 cm for small bodied salmonids and 18 cm for large bodied salmonids. Potential spawning gravel particle size criteria was based off an abridged Wentworth size classification scale of > 8-64 mm (.3”- 2.49”) for small bodied salmonids, and > 64 mm-128 mm (2.5”-5.0”) for large bodied salmonids (US Forest Service 1991). Dominant substrate was determined by surface area, not the number of individual substrate particles.

Riparian Condition

We identified riparian streamside structure, vegetated width, and tree type on both banks at each habitat unit using DDES methods (King County undated). Observations of streamside structure adjacent to the each habitat unit were classified as follows based on riparian composition and visual estimates of stand age: no riparian zone, mature complex forest, immature/even aged/disturbed, shrub dominated, grassland/meadow pasture, and wetland. A visual estimate of the riparian corridor width was also recorded, along with the dominant tree types (conifer, deciduous, or unknown).

Large Woody Debris (LWD)

Information on instream LWD was collected throughout each reach to document current characteristics, distribution patterns, and abundance of LWD in the Mapes Creek system. Utilizing LWD criteria outlined in the DDES *Stream Survey Report Criteria* document (King County undated) the following parameters were recorded for each individual piece of large woody debris $\geq$10 cm encountered within the bankfull width: location; length; mean diameter; stability (anchored, unanchored, unknown); type (jam, floating, stranded); species (conifer, deciduous, or unknown); and the presence of a rootwad (yes, no, or unknown). Log length was measured using a stadia or Spencer tape; total length was not measured for logs greater than 14.5 ft. Log diameter was measured using log calipers or the diameter side of a Spencer tape. Each log was only counted once; to avoid duplicating data, logs that crossed more than one habitat unit were counted only in the unit where the mid-point landed.

Barriers to Fish Passage

The definition of a fish passage barrier can vary considerably among organizations and methodologies. For the purposes of this study, the Washington Trout Culvert College Manual (2002) definition was used, which defines a fish passage barrier as follows: “anything that causes an excessive delay and/or abnormal expenditure of energy during migration or in spawning areas.” Culverts, pipes, man-made structures such as weirs, and natural features which could negatively influence the potential passage of adult and/or juvenile salmonids were assessed and placed in one of three barrier status categories (barrier, non-barrier, unknown). Surveys were performed using a modified version of the Washington State Department of Fish and Wildlife’s protocol described in the Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual (August 2000).

In December of 2002, a total of four culverts, four concrete weirs, and five artificial channels were assessed (Map 2). Each structure or potential fish barrier was field mapped and documented with a GPS location point. Field measurements included, to the extent possible at each site, structure material, length, width or diameter, and outfall drop. In addition, when applicable data or field notes were taken on stream width, the presence or absence of substrate, sediment depth, gradient, pool characteristics, and maintenance issues. When warranted, surveyors drew a schematic plan-view to document unique site features. Additionally, photographs of each feature were taken.

Fish Species Composition and Distribution

The fish composition and distribution survey, performed on October 30th 2002, extended from the Sturtevant/Rainier culvert inlet upstream to the headwaters of both the east and west branch tributaries with exception of the following: 1) the reach where access was denied extending 60 ft upstream of the Roxbury culvert inlet to the Renton Avenue culvert inlet 2) the two Koi Ponds which were not electrofished to avoid injuring the Koi and 3) the artificial waterfall tributary, which was dry at the time of the survey. The electrofishing crew surveyed upstream using a Smith-Root Electrofisher, Model 12B-POW. The electrofisher was set at G7, with an initial voltage of 300, which was increased to 400, than 500, and ultimately 600 volts at pond #3. Voltage remained at 600 for the remainder of the survey. Prior to beginning the electrofishing survey, conductivity and temperature measurements were collected in mainstem Mapes at the Sturtevant / Rainier culvert inlet using a hand held Oakton conductivity meter, model WD-35607-10. Conductivity at the inlet to the Sturtevant Rainier culvert was 284 µs. Additional temperature readings were taken at the outlet of the duck pond and in the west branch tributary, 100 ft upstream of the east and west branch tributary junction. Fish visually sighted or electrofished were identified to species and, when brought to hand, photographed. In addition, a Global Position System (GPS) location point was taken to document distribution.

Results

Reach Designations

Mapes Creek was broken into 8 separate reaches and 2 sub-reaches for the purpose of this investigation (Map 1). Reach 1, the downstream-most reach included in the survey, extended from the Sturtevant/Rainier culvert to the Roxbury Street culvert. Reach 2 was the portion of the creek upstream of the Roxbury culvert and downstream of the Renton Avenue culvert for which landowner permission was granted. Reach 3 was the reach upstream of Renton Avenue and downstream of the Kubota Gardens. Reach 4 was the portion of the creek in the Kubota Gardens that was not incorporated into the park's pond system. All waters of mainstem Mapes Creek that were incorporated into the Kubota Garden's artificial ponds, streams, and waterfalls were designated as Reach 5. The two spring fed Koi ponds and the culverts that connected them to the Mapes system were designated as Reach 5A. Reach 6 encompassed the length of free-flowing stream in the park above the pond system and below the confluence of the upper forks of Mapes Creek. The Duck Pond and its outflow into Mapes Creek were designated as reach 6A. Reach 7 was the West Fork of Mapes Creek and Reach 8 was the East Fork of Mapes Creek.

Habitat Types

Within the 8 reaches, 33 individual habitat units made up of five different habitat types were documented (Table 1, Figure 1). The dominant habitat types observed in the free flowing portions of Mapes Creek are riffle type habitats, which include riffles, riffle glides, and riffle cascades. Riffle type habitats comprise 78% of the total habitat types within the Mapes Creek study reaches. Riffle habitats in Mapes Creek tend to be straight, with little difference between wetted width and ordinary high water width. The other dominant habitat in the system is sediment pool habitat. This description was given to relatively broad, shallow portions of the creek that flow over a deep layer of mixed silt and organic sediments, often with emergent vegetation (Photos 14). The observed sediment pools are the result of three forming factors: flow constraint, gradient, and sediment supply. Flow constraints cause a loss of hydraulic energy and result in the deposition of the stream's suspended load. In Reach 3 these constraints are concrete weirs that span the width of the stream. In Reach 1, two factors have caused the formation of the largest sediment pool in the system: the low gradient where the sides of the ravine pinch together, and the rock weir just upstream of the Sturtevant/Rainier culvert. The other forming factor for these pools is an abundance of fine sediments from the watershed. These sediments were likely mobilized during the construction of both the surrounding neighborhoods and Kubota Gardens, and may be exacerbated by the addition of sediment-laden stormwater runoff. All of Reach 5, the portion of the stream that is incorporated into the Kubota Garden's channels, ponds, and waterfalls, was classified as landscaped habitat. The 8 ponds have an average water depth of 2 ft, vary in size from 45 x 30 ft to 90 x 50 ft in approximate area, and are hydraulically connected by artificial concrete channels, waterfalls, and piped culverts.

The final habitat classification was plunge pool. There is only one habitat unit that received this classification. The plunge pool unit is in reach six, where the Duck Pond tributary flows into the main stem of Mapes Creek. The culvert outlet is perched 1 ft above the water level (Photo 4), and the force of the falling water has created the only non-cemented pool in the system that it is not filled with sediment.

Table 1. Habitat Characteristics by Reach

Attribute	*Reach 1*	*Reach 2*	*Reach 3*	*Reach 4*	*Reach 5*	*Reach 6*	*Reach 7*	*Reach 8*
Length (ft)	440.3	60	400	107	N/A	310	400	284
% Riffle	10.3	24	23	37.4	0	90.3	100	33
% Riffle Glide	18	76	0	63	0	6	0	66
% Riffle Cascade	31	0	19	0	0	0	0	0
% Sediment Pool	40.2	0	55.8	0	0	0	0	0
% Plunge Pool	0	0	0	0	0	3.2	0	0
% Landscaped	0	0	0	0	100	0	0	0
Mean Wetted Width (ft)	8.2	6.2	13.8	5.4	0	4.2	1.9	3

Stream Flow Measurements

Despite the fact that flows were measured in October, the observed flows were more representative of summer low-flow conditions because by October 30th Seattle had received < 50% of normal rainfall for the three-month period beginning in August 2002 (National Weather Service Northwest River Forecast Center). At the point where Mapes Creek flows into the Sturtevant/Rainier culvert, flow was estimated to be 0.38 cubic feet per second (cfs). Where the upper Koi Pond flows into the lower Koi Pond the flow was estimated to be 0.007 cfs. The outflow of the Duck Pond was measured at 0.054 cfs, while the inflow to the pond was measured at 0.004 cfs, suggesting that a significant fraction of the water from the Duck Pond tributary is derived from springs in the Duck pond. The East Fork of Mapes Creek was estimated to flow at 0.08 cfs, while the West Fork was estimated at 0.054 cfs (Table 2, Map 4).

The presence of headwaters dominated by wetland seeps, an intact riparian corridor along much of survey reaches, and the observed similarity between the wetted width and bankfull width in the upstream reaches suggest that the flow regime within Mapes is relatively stable, and unusual scenario in such an urban landscape.

Map 4 shows where each field observation was taken, with site IDs in Table 2 matching site Ids in Map 4.

Table 2. Flow Measurements taken in Mapes Creek

Location	Site ID	Flow (Gallons/minute)	Flow (Cubic feet/second)
Sturtevant/Rainier Culvert	1	143.5	0.384
Koi Ponds	2	2.5	0.007
Duck Pond Outflow	3	20	0.054
Duck Pond Inflow	4	1.67	0.004
East Fork Mapes Creek	5	30	0.08
West Fork Mapes Creek	6	20	0.054

Substrates/Spawning Gravels

The substrates in Mapes Creek vary in size from cobble to silt/organic sediments. No suitable salmonid spawning gravels were documented within the survey reaches. While the upper reaches have substrates of an appropriate size for smaller salmonids such as cutthroat trout, these gravels are deeply embedded in a matrix of fine silt. There is an abundance of silts in Mapes Creek, with low velocity habitat units dominated by silt substrates, and units with moderate to fast flow with substrates dominated by gravel and cobble embedded in a mix of silt and sand. It is likely that the source for these sediments is construction in the surrounding watershed. The apparent lack of high flows in the system results in little opportunity for the flushing of fine sediments out of the channel. The sediment pools dramatically demonstrate the abundance of silt/organic sediments in the system. In many places the sediment depth was greater than 3 ft deep, with two units having sediments at least 4 ft deep. Approximate estimates of stored sediment behind each of the weirs were made using channel width, length of the sediment pool, and depth of the sediment. There is approximately 200 ft^3 of sediment are estimated to be stored behind concrete weir 1, 16300 ft^3 of sediment stored behind concrete weir 2, and 4950 ft^3 of sediment stored behind concrete weir 3 (Map 2).

Riparian Condition

The riparian area of Mapes Creek was surprisingly intact for a stream in such a highly urbanized setting (Figures 2 and 3). The riparian corridor in Reach 1 was over 88% mature forest, with mean riparian widths in the mature forest units averaging over 50 ft on each side. The area that was identified as having no riparian vegetation is the result of recent clearing that has occurred around the entrance of the Sturtevant/Rainier culvert, which was the site of an improvement project (See Table 3 for % vegetation cover by reach, and riparian widths by vegetation type). Reach 2 had similar riparian characteristics, with average mature forest riparian width of 65 ft on each side. At 13.8 %, the third reach had the largest percentage of non-vegetated riparian area of any of the reaches. This was due to a lawn that extended to the side of the stream behind a residence. There was also a considerable amount of immature-disturbed vegetation in the riparian area of Reach 3 (30%), which could also be attributed to landscaping around residences. The entire riparian area in Reach 4 was classified as immature-disturbed. Recent clearing activity in the park has left the riparian area within Reach 4 devoid of most vegetation. The exception to this is a thick low-lying mat of blackberry bushes. Reach 5 was also classified as having immature-disturbed vegetation along the entirety of its riparian zone. There is considerable vegetation along this reach, but it is all non-native landscaped vegetation that is maintained in the park. While this vegetation does provide shade for the stream, because of the artificial nature of the reach it does not provide the same functions, such as stabilization and LWD recruitment, that vegetation in a natural reach would. Reach 6 had over 60% mature forest in its riparian zone, with a mean width of over 90 ft in the mature forest units. The immature-disturbed riparian areas in Reach 6 were plantings maintained in the Kubota Garden Park. Reaches 7 and 8 had the most intact riparian areas of all of the reaches, with 100% of both reach's riparian zone classified as mature forest. There were considerable lateral wetlands along both reaches with skunk cabbage (*Symplocarpus foetidus*) being the dominant species. These wetlands occur along seeps, and run almost continuously on both of the upper forks. Mature forest in all reaches was composed mostly of big-leaf maple (*Acer macrophyllum*), and red alder (*Alnus rubra*), although there are a few conifers, including western red cedar (*Thuja plicata*), and western hemlock (*Tsuga heterophylla*).

Table 3. Riparian Characteristics by Reach

Attribute	*Reach 1*	*Reach 2*	*Reach 3*	*Reach 4*	*Reach 5*	*Reach 6*	*Reach 7*	*Reach 8*
% of Reach w/no Vegetation	1.2	0	13.8	0	0	0	0	0
% of Reach w/Immature-Disturbed	10.8	15	30	100	100	35.5	0	0
% of Reach w/Mature Forest	88	85	56.3	0	0	64.5	100	100
Mean Riparian Width for Non-Vegetated (ft)	30	0	42.5	0	0	0	0	0
Mean Riparian Width for Immature-Disturbed (ft)	30	65	52	37.5	0	16	0	0
Mean Riparian Width for Mature Forest (ft)	51.2	65.0	55.0	0.0	0	92.1	100	68.3
Mean Riparian Width (ft)	45.3	65	52.5	37.5	0	60.4	100	68.3

Large Woody Debris

The amount of large woody debris varies widely between reaches (Figure 4). Reach 1 has the most LWD, and the highest concentration of any reach, with the bulk of the wood being trapped in the large sediment pool that makes up 40% of the reach's length (see Table 4 for LWD characteristics by reach). Reach 2 only has 1 piece of LWD, a conifer that is substantially larger than most other pieces observed in the system. Reach 3 was similar to Reach 1 in that most of the woody debris in this reach was trapped in sediment pools. Reach 4 had a lack of woody debris as would be expected due to the artificial nature of the upstream pond system and lack of a riparian area resulting in little recruitment opportunity for the reach. No pieces of LWD were observed in Reach 5, likely because park-landscaping staff removes any that fall in. Reach 6 is more lacking in LWD than would be expected for a naturally forested area. The two upper reaches of Mapes Creek show a slight increase in woody debris density over Reach 6, but LWD is still less abundant than would be expected in a forested headwater.

While there may be some LWD in the Mapes Creek system, it is not of the size and abundance needed to increase instream habitat complexity. LWD plays a primary role in the formation of quality salmonid habitat by creating scour pools, providing cover from predators, and impeding the flux of sediments down a stream channel. The lack of a single pool habitat unit dramatically demonstrates how the functional role of LWD is not being fulfilled in this system. The overall lack of woody debris in the system is probably a result of historic timber harvesting in the area. We don't have a record of when the area was logged, but stumps were observed in the upper watershed, and the Kubota Gardens information board states that the first thing the garden builders did was remove stumps from the park area.

Table 4. LWD Characteristics by Reach

Attribute	*Reach 1*	*Reach 2*	*Reach 3*	*Reach 4*	*Reach 5*	*Reach 6*	*Reach 7*	*Reach 8*
Number of Pieces of LWD	24	1	8	1	0	3	9	7
Pieces of LWD/100 ft	5.5	1.7	2.0	0.9	0	1.0	2.3	2.5
Median Length (ft)	>14 ft	N/A	>14 ft	>14 ft	N/A	9.5	>14 ft	>14 ft
Mean Diameter of LWD (in)	8.4	19.4	13.8	8.6	N/A	12.3	13.8	11.3

Barriers to Fish Passage

A total of seven culverts, four concrete weirs, and five artificial channels were assessed as potential barriers to fish passage (Map 2).

Culverts:
The Sturtevant/Rainier culvert, which runs from Lake Washington to the first daylighted section of Mapes Creek, is approximately 3240 ft long, and could only be examined from its inlet (photos 15, 16, and 17). The culvert is 2.5 ft in diameter and made of pre-cast concrete. In the visible area near its entrance the culvert was ¼ filled with a mix of sand and cobble substrate. The majority of the culvert was not visible to our survey crews, but combined with the rock weir that serves as an upstream grade control for this culvert it was determined to be a full barrier to fish passage. The rock weir appears to have been recently installed as part of a project that pulled back the headwall surrounding the culvert entrance.

The next culvert upstream is the Roxbury Street culvert, which is approximately 187 ft in length (Photos 18 and 19). The Roxbury culvert is a 2.5 ft diameter pre-cast concrete pipe with an angular bend in the middle. The pipe visible from the outlet has no substrate and a 0.5 ft deep plunge pool, with a drop of 0.55 ft from water surface to water surface. The inlet is blocked by a wooden trash rack, and has a negative perch of 2.5 ft with no visible substrate in the pipe. The outlet would be a migration barrier to juveniles under low flows because of the plunge and a lack of substrate within the culvert, but would probably not hinder adult migration. The inlet would likely be a full migration barrier for both adults and juveniles because of the 2.5 ft invert drop and the presence of the trash rack.

The next culvert upstream is the Renton Avenue culvert, which is approximately 233 ft long (Photo 20). The outlet of this culvert was not surveyed because the landowner denied permission to access the property. On the upstream end it was noted that the culvert consisted of a 2.5 ft diameter pre-cast concrete pipe with no substrate throughout. It is believed that this culvert would be a partial velocity barrier due to its apparent gradient and a lack of substrate.

Within the Kubota Gardens four additional culverts were assessed. The two pipes that connected the Koi Ponds to Mapes Creek had outlets that flowed through 6-inch diameter pipes that were perched at a height greater than 0.5 ft (Photo 8). Because of the size of these pipes they were considered full barriers to salmonid migration. There was a culvert at the inlet of the pond system. This culvert was a 16-inch corrugated metal pipe that was half full of sediment with a 0.6 ft plunge at the inlet (Photo 33). Due to the plunge this culvert was considered a partial barrier to salmonid migration. The final culvert observed was another 6-inch diameter pipe that carried flow into the Duck Pond tributary. This culvert was considered a barrier to passage due to the size of the pipe.

Dams/weirs:
The first in a series of four concrete weirs within Reach 3, concrete weir 1 is 65 ft upstream from the Renton Avenue culvert (Photos 22 and 23). This weir is 3.7 ft high, 0.65 ft thick and 32 ft long. The intended outflow is a notched rock and concrete ladder that is no longer functioning. The creek now runs down the right bank side of the weir through a failed patch of sandbags and poured concrete. There is no plunge pool at the outlet of the weir and in its current state; the weir is a full barrier to adult and juvenile salmonid migration.

Concrete weir 2 is 112 ft upstream from concrete weir 1(Photos 24 and 25). This weir has a combined drop of 7 ft, is 0.5 ft thick, and 45 ft long. There is a rocky outfall beneath the weir where the stream flow is obscured and presumably goes underground. The actual weir height is 4 ft, with a rock step at the base of the weir 3 ft in height. Below the rock step is the rocky outfall where the stream is obscured, which adds 1 ft of elevation to the total drop of the structure. There is slight flow over the right edge of the weir but the amount of water flowing from the base of the rockfall suggests that some flow is going under the weir. There is no plunge pool at the base of the weir outflow and the weir is a full barrier to salmonid migration.

Concrete weir 3 is 70 ft upstream of concrete weir 2 (Photo 26). This weir has an unusual prow design: there is a bend halfway across the weir and the dam itself is not straight up and down, but is configured in a way similar to the bow of a ship. The outflow is from a notch in the middle of the dam, which is perched 4.5 ft above the stream below. There is no plunge pool at the base of the weir, making the weir a full barrier to fish passage.

The fourth and final concrete weir is 113 ft upstream of concrete weir 3 (Photo 27). The height of concrete weir 4 is 4.4 ft from downstream substrate to the top of the weir. No water was flowing over the weir at the time of the survey, and all flow is believed to be subsurface. There is minimal water and sediment storage behind weir 4 with substrate heights behind the weir only 0.1 ft higher than substrates downstream from the weir. Due to the subsurface flows at this weir site, weir 4 is a barrier to fish passage.

Artificial Ponds and Channels:
Reach 5, the Kubota Gardens artificial pond and channel system, also has numerous barriers to fish passage. At the outflow of pond 1 there is a 12 ft long concrete flume into a rockfall with a 9% gradient over 40 ft that was classified as a partial barrier (Photo 27). Between pond 1 and pond 2 there is an artificial channel with an 11% gradient over 20 ft that was also considered a partial velocity barrier due to sheet flow in the concrete channel (Photos 28 and 29). The concrete channel connecting ponds 2 and 3 has a 0.5 ft step with a 0.4 ft deep plunge pool and was considered a partial barrier to juvenile migration (Photo 30). The artificial channel and the waterfall between ponds 3 and 4 were classified as full barriers. The waterfall height from water surface to water surface was 4.9 ft (Photo 31). The connection between ponds 4 and 5 had a gradient of 12% over 20 ft. and was considered a partial velocity barrier (Photo 32).

Fish Species Composition and Distribution

In Section 13 of the Washington Forest Practice Board Manual, the Washington Department of Natural Resources designates March 1st through July 15th as the survey window for determining the presence or absence of fish in streams for the purpose of water typing. Because the Mapes Creek fish species composition and distribution surveys were not done within this time window, they are inconclusive for the purpose of water typing. The results of our survey do not exclude the possibility of salmonids being in the system, especially considering the difficulty of an exhaustive census of pond habitats with an electrofisher. Moreover, the habitat conditions observed would not preclude the presence of salmonids, the water temperatures were well within the range acceptable for salmonids, and one Kubota Gardens employee mentioned sighting a small trout in one of the park's ponds several years ago.

Only two fish species were observed in the Mapes Creek watershed during the December 2002 survey: threespine stickleback (*Gasterosteus aculeatus*), and Japanese Koi (*Cyprinus carpio*). A map of fish distribution within the watershed was generated to illustrate all fish observations (Map 3). Nearly all the observed specimens were in the artificial ponds of Kubota Gardens. The Koi were only observed in the two of the park ponds, while the stickleback were observed in 5 of the 8 park ponds. One stickleback was observed outside of the pond system, in the large sediment pool of Reach 1. This fish was brought to hand using the backpack electrofishing unit. The electrofisher was used in all of the natural stream reaches and the Kubota Garden ponds for a total of 345 seconds of electrofishing time.

Conclusions

Mapes Creek shows a pattern of basin alteration and subsequent loss of habitat complexity and biological diversity that is common to urban streams in the Puget Sound lowland. Calculating total impervious area for the Mapes Creek watershed was outside the scope of this assessment, but baseflow conductivity has been shown to be an excellent indicator of percent total impervious area (May 1996). The conductivity of Mapes Creek fell out on the extremely high end of values for the Puget Sound lowland, indicating that the impervious area for the basin was likely over 60%. As was seen in this assessment, at such high rates of urbanization, instream habitat quality and natural biological integrity decline sharply (May 1996).
As dramatically indicated by the lack of a single natural pool, Mapes Creek suffers from considerable habitat homogenization. Pool frequency and percent pool habitat in a stream reach are good indices of the quality of salmonid rearing habitat in a system (May 1996). The simplification of habitat types in Mapes Creek is a symptom of the deficiency of LWD in the system. LWD indices identified by May include number of pieces of LWD/Bank Full Width (BFW), and % key pieces of LWD with key pieces defined as those with a diameter greater than 19.7 inches (0.5 meter). Mapes Creek fell into the poor habitat quality category for both these indices, with 0.35 pieces of LWD/BFW (<1 piece/BFW was considered poor), and 3 % of the LWD categorized as key (<20% key LWD was considered poor). Riparian condition was also an important attribute to determine the status of the watershed. This is the one hopeful note for the upper portion of the watershed. The mature forest and large riparian widths indicate a potential for LWD recruitment and the development of quality habitat in the future. But the realization of these benefits could be severely limited by conditions in the lower watershed.

In its current state, the portion of Mapes Creek included in this assessment was found to offer poor habitat potential for anadromous salmonids, as exemplified by the pervasiveness of barriers to fish passage and the lack of instream habitat heterogeneity (specifically the lack of pool habitat, spawning habitat, and instream cover) important for salmonid rearing, spawning, and flow refuge.

In contrast, the Mapes Creek headwater hydrology appeared to be heavily influenced by groundwater, likely providing relatively stable and low-temperature flows year-round and potentially minimizing the occurrence of high flow scouring events prevalent in urban watersheds. In a similar positive note, a large proportion of the upper Mapes watershed riparian areas were found to be intact and healthy. While an assessment of water quality was outside of the scope of this project, it is possible that the upper Mapes watershed is currently or could support a resident population of cutthroat trout (*Onchorynchus clarki*), although the present-day low quantity and quality of spawning habitat would limit their abundance.

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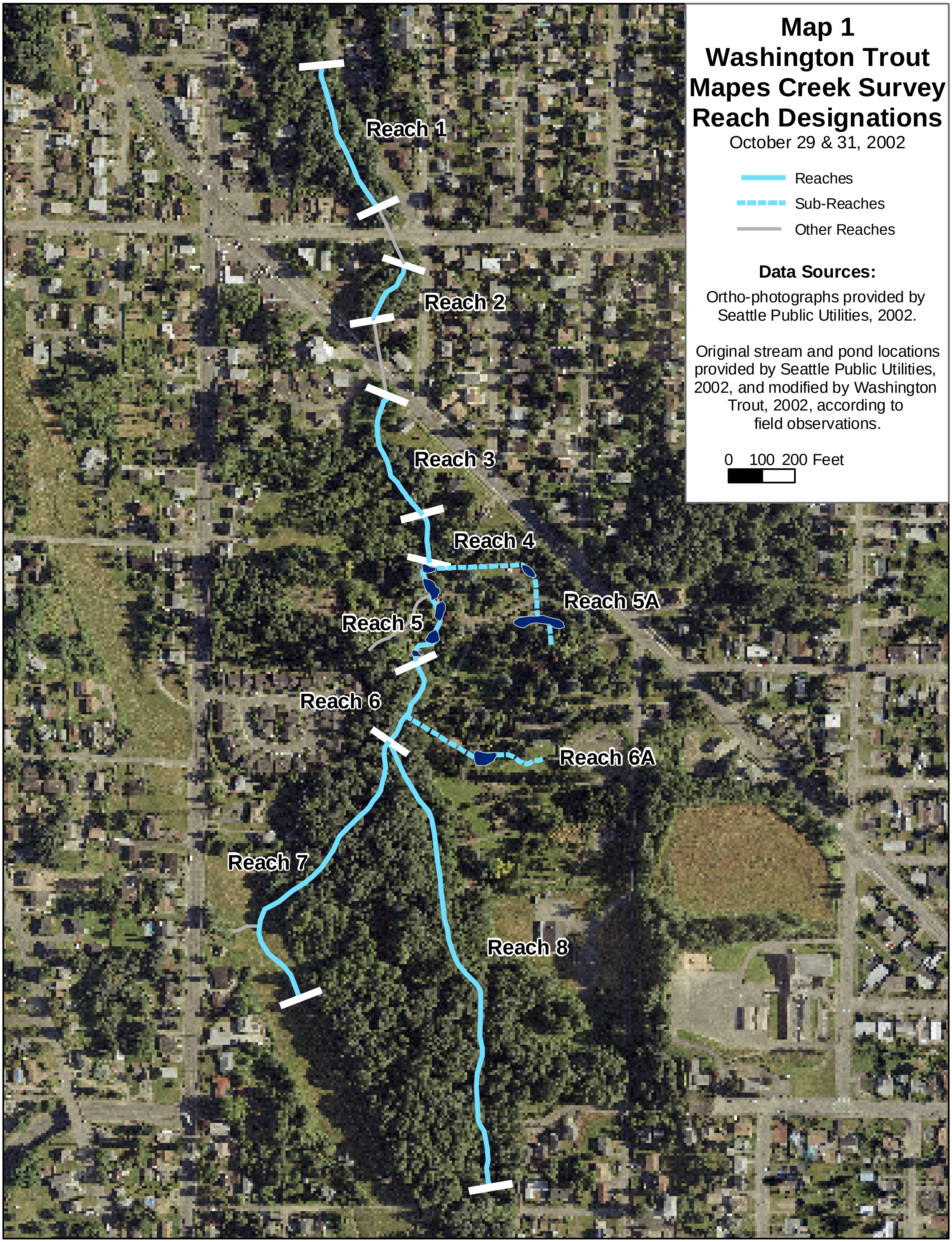
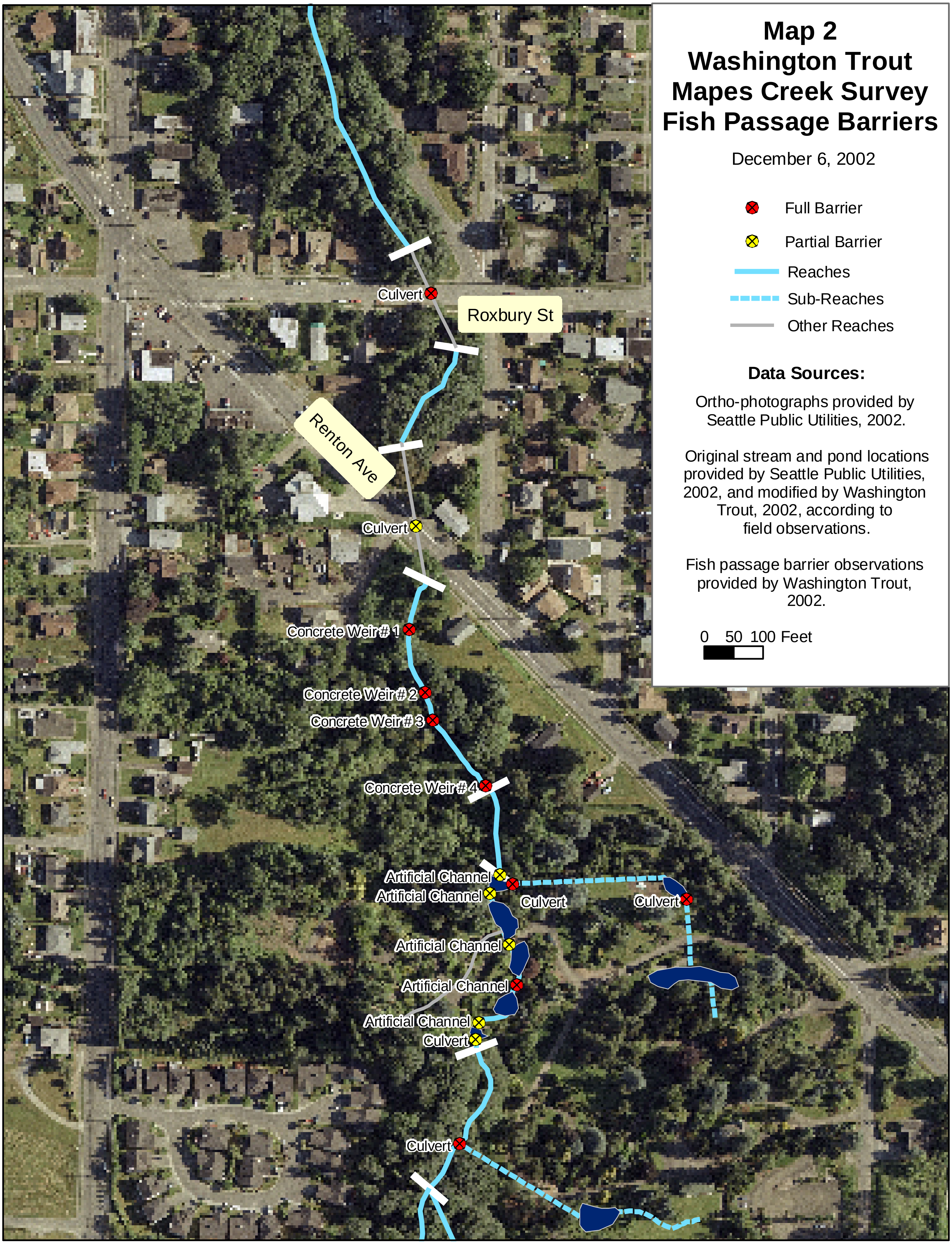
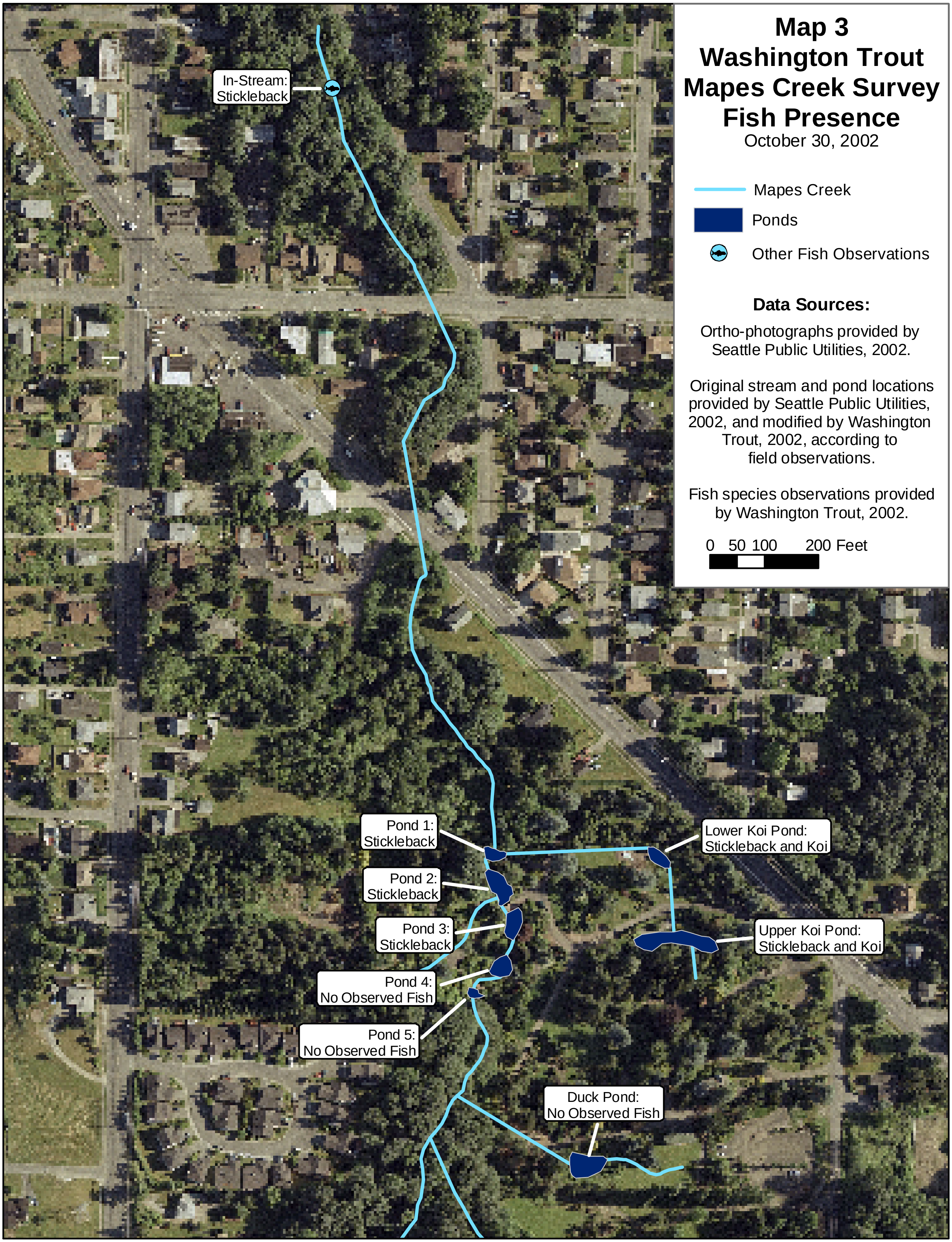
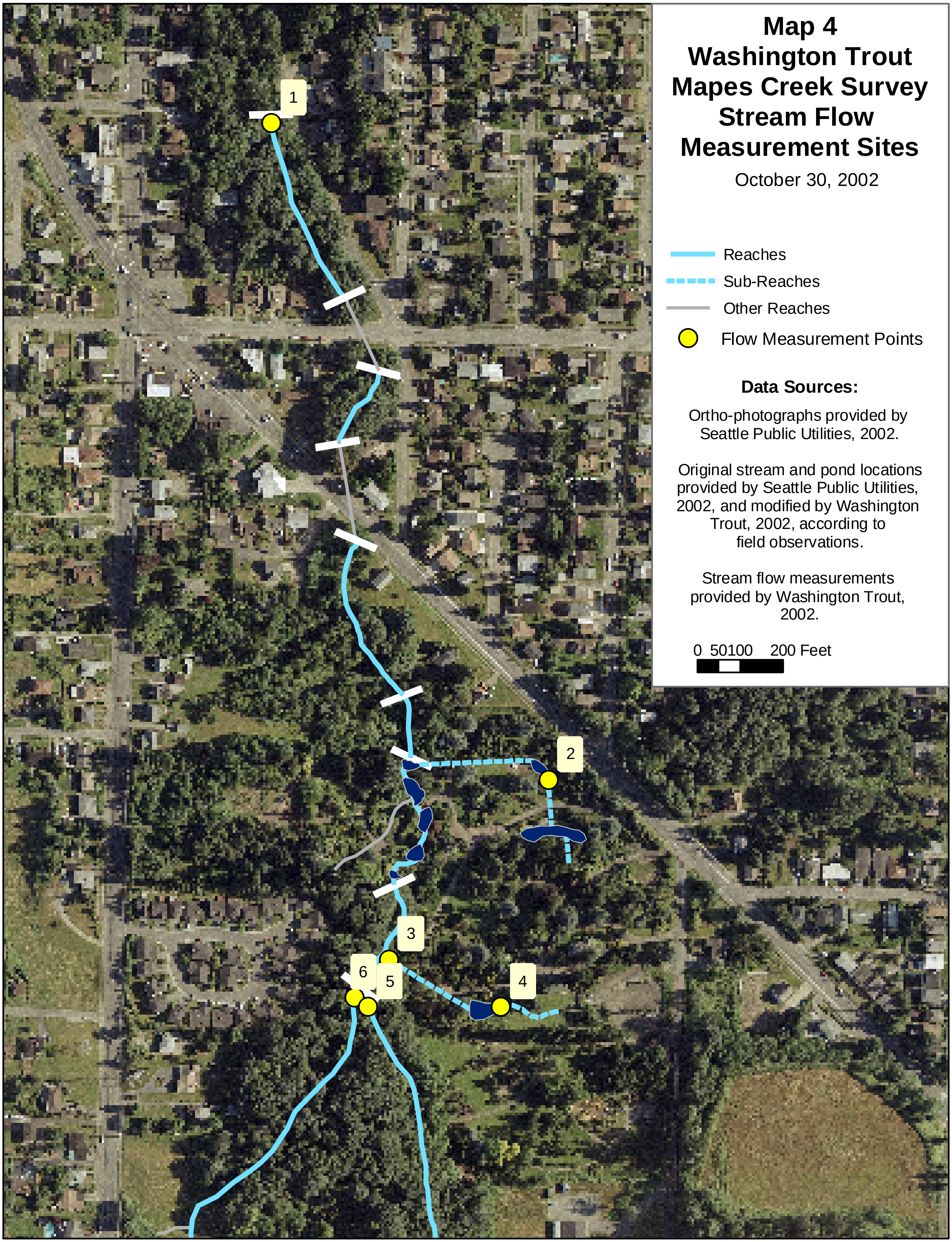
Appendix A: Maps



Map 1
Washington Trout
Mapes Creek Survey
Reach Designations
October 29 & 31, 2002
Reaches
Sub-Reaches
Other Reaches
Data Sources:
Ortho-photographs provided by Seattle Public Utilities, 2002.
Original stream and pond locations provided by Seattle Public Utilities, 2002, and modified by Washington Trout, 2002, according to field observations.
0 100 200 Feet
Reach 1
Reach 2
Reach 3
Reach 4
Reach 5A
Reach 5
Reach 6
Reach 6A
Reach 7
Reach 8


Map 2
Washington Trout
Mapes Creek Survey
Fish Passage Barriers
December 6, 2002
Full Barrier
Partial Barrier
Reaches
Sub-Reaches
Other Reaches
Data Sources:
Ortho-photographs provided by Seattle Public Utilities, 2002.
Original stream and pond locations provided by Seattle Public Utilities, 2002, and modified by Washington Trout, 2002, according to field observations.
Fish passage barrier observations provided by Washington Trout, 2002.
0 50 100 Feet
Roxbury St
Renton Ave
Culvert
Culvert
Concrete Weir # 1
Concrete Weir # 2
Concrete Weir # 3
Concrete Weir # 4
Artificial Channel
Artificial Channel
Culvert
Culvert
Artificial Channel
Artificial Channel
Artificial Channel
Culvert
Culvert


Map 3
Washington Trout
Mapes Creek Survey
Fish Presence
October 30, 2002
Mapes Creek
Ponds
Other Fish Observations
Data Sources:
Ortho-photographs provided by Seattle Public Utilities, 2002.
Original stream and pond locations provided by Seattle Public Utilities, 2002, and modified by Washington Trout, 2002, according to field observations.
Fish species observations provided by Washington Trout, 2002.
0 50 100 200 Feet
In-Stream: Stickleback
Pond 1: Stickleback
Pond 2: Stickleback
Pond 3: Stickleback
Pond 4: No Observed Fish
Pond 5: No Observed Fish
Lower Koi Pond: Stickleback and Koi
Upper Koi Pond: Stickleback and Koi
Duck Pond: No Observed Fish


Map 4
Washington Trout
Mapes Creek Survey
Stream Flow
Measurement Sites
October 30, 2002
Reaches
Sub-Reaches
Other Reaches
Flow Measurement Points
Data Sources:
Ortho-photographs provided by Seattle Public Utilities, 2002.
Original stream and pond locations provided by Seattle Public Utilities, 2002, and modified by Washington Trout, 2002, according to field observations.
Stream flow measurements provided by Washington Trout, 2002.
0 50100 200 Feet
1
2
3
4
5
6

Appendix B: Figures

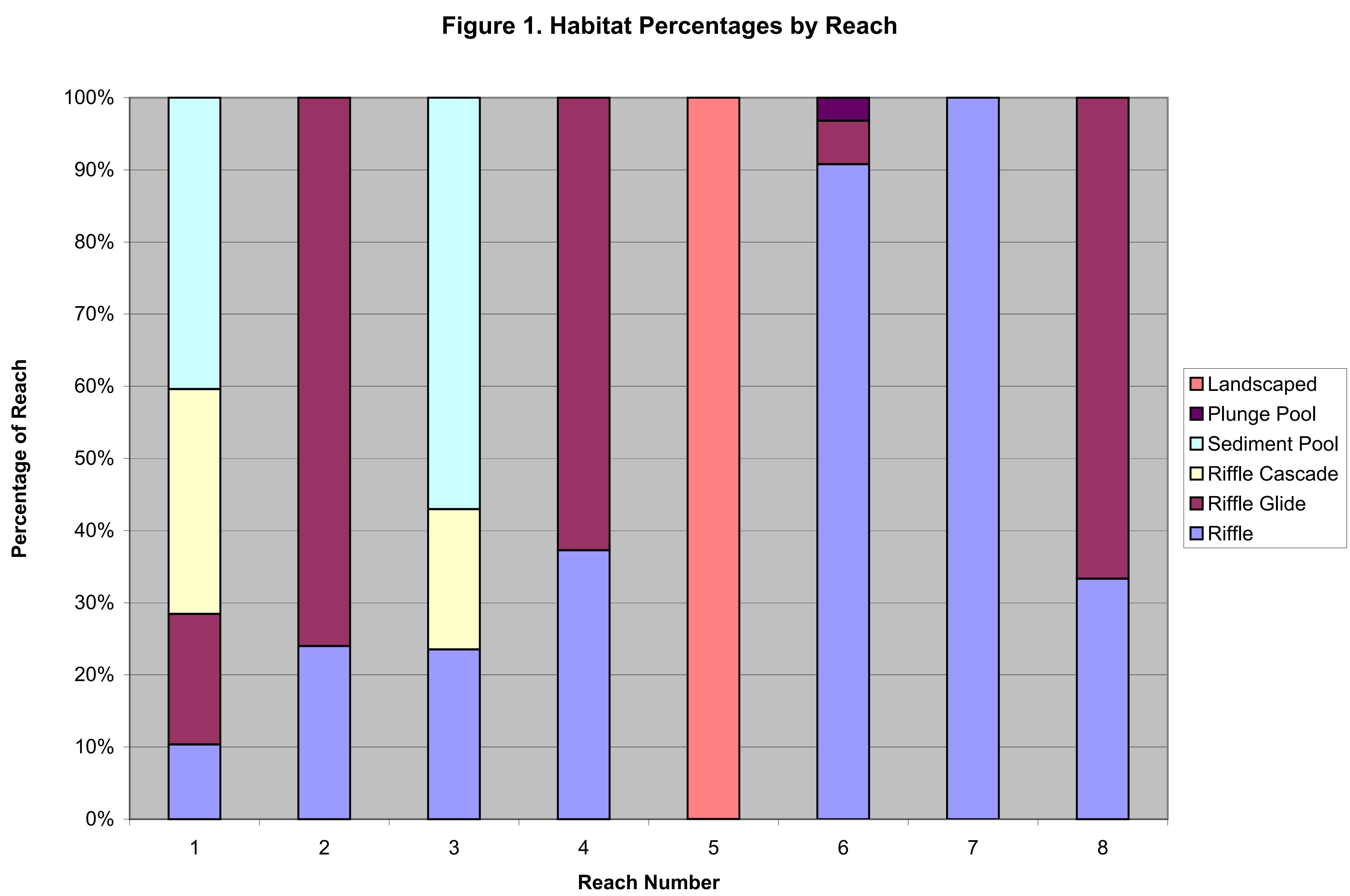


Figure 1. Habitat Percentages by Reach
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of Reach
1
2
3
4
5
6
7
8
Reach Number
Landscaped
Plunge Pool
Sediment Pool
Riffle Cascade
Riffle Glide
Riffle

Figure 2. Riparian Cover by Reach

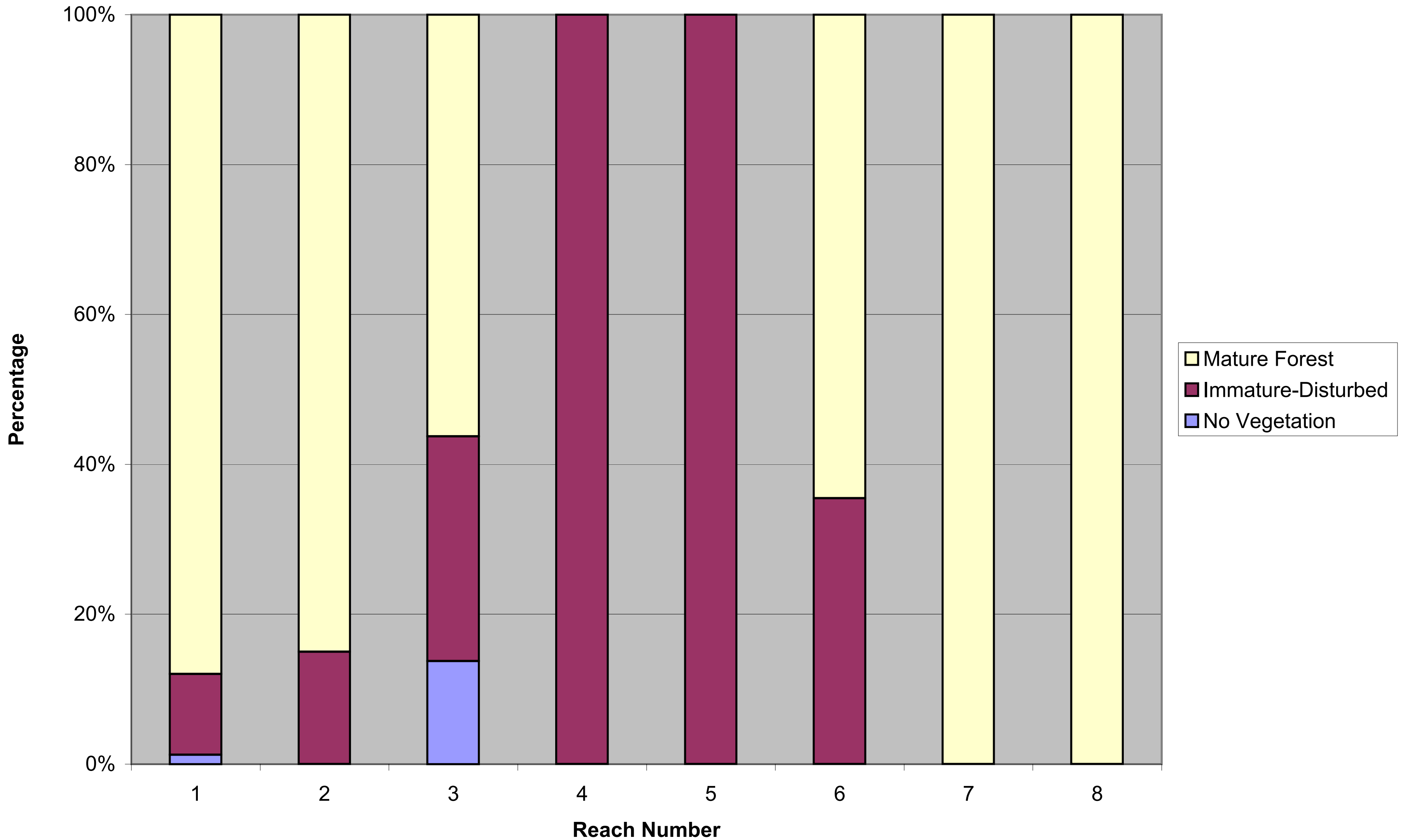


Figure 3. Mean Riparian Width by Vegetation Type

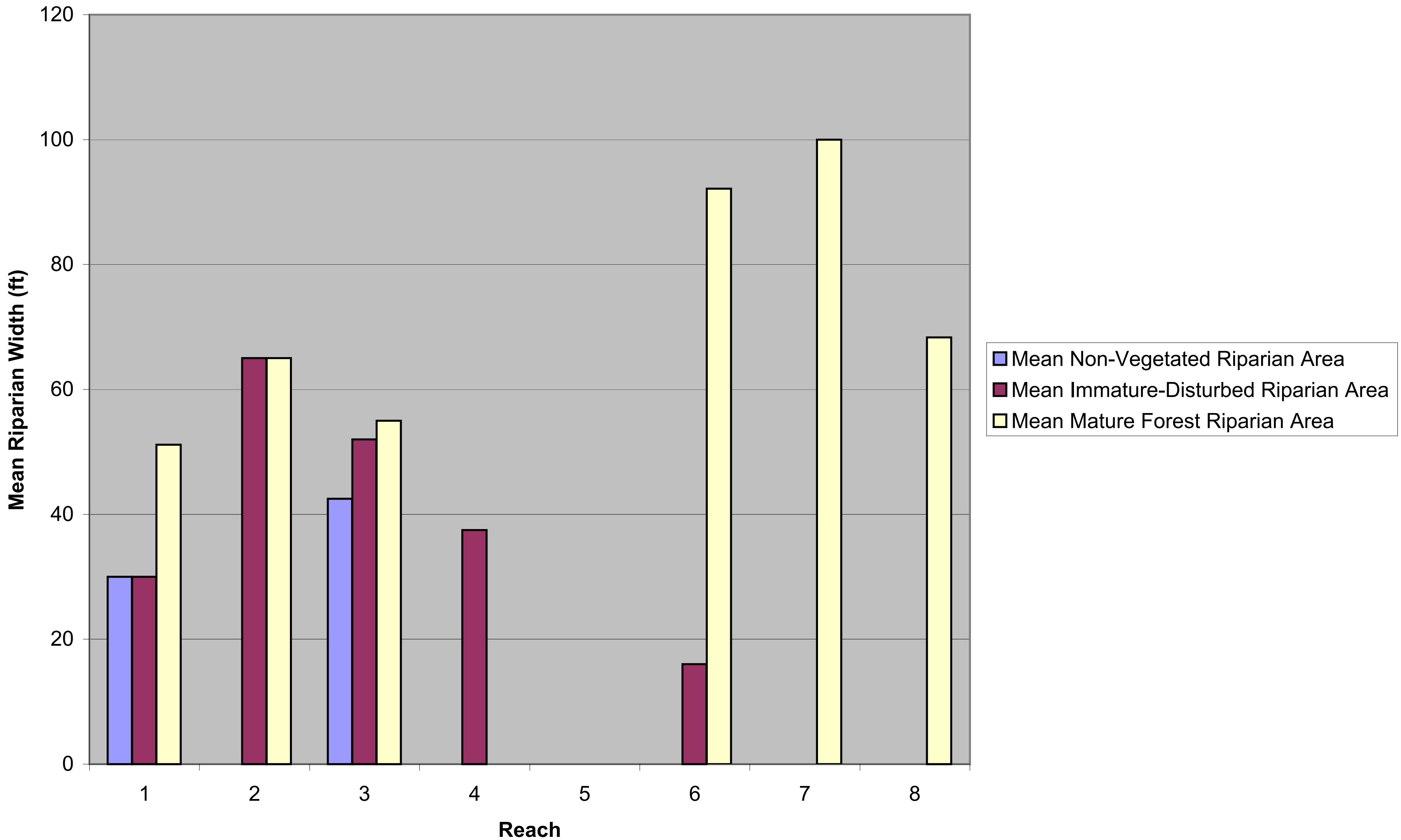
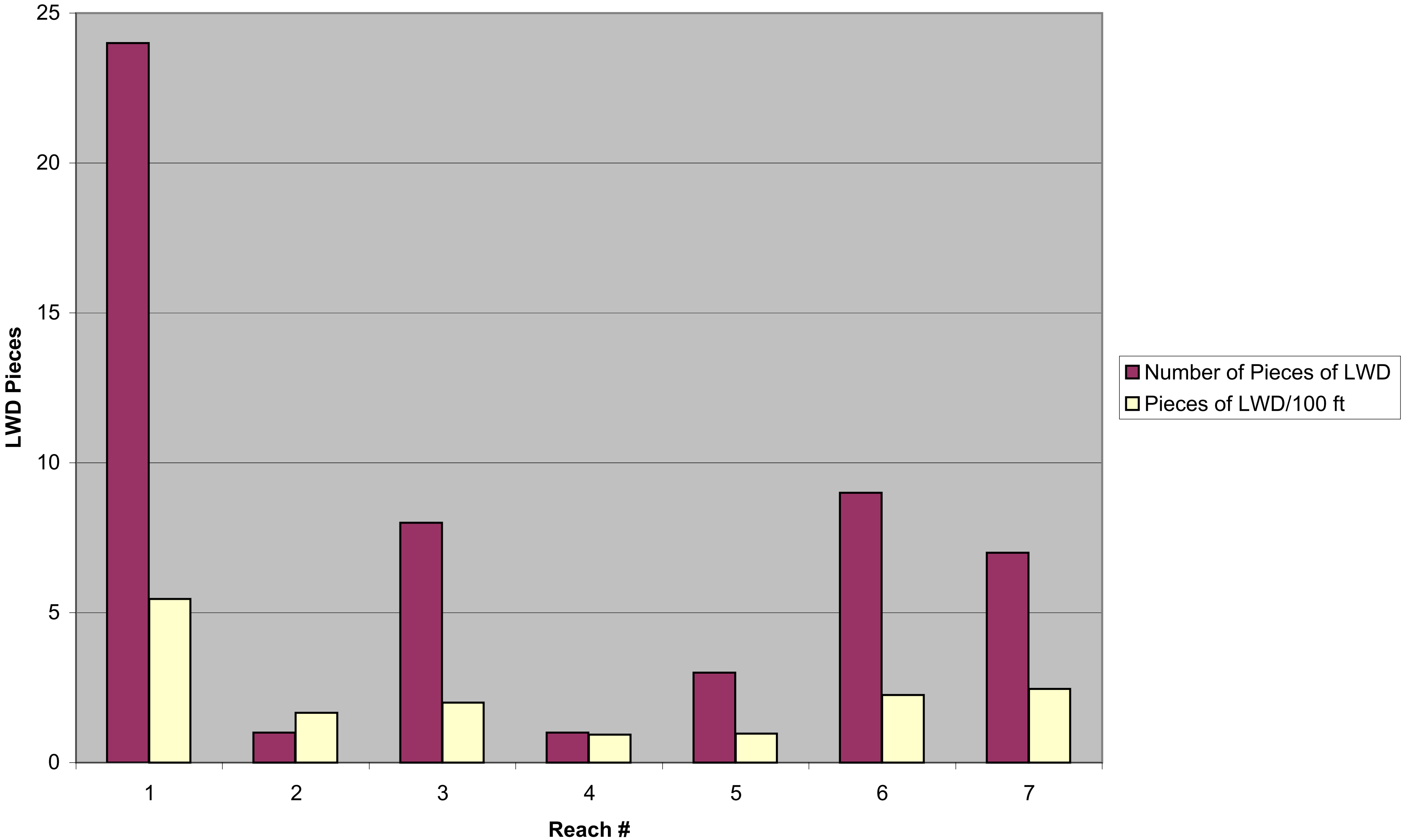


Figure 4. LWD Characteristics



Appendix C: Photos

Photo 1. Upper Mapes Creek watershed. The East Fork is in the foreground and the West Fork is flowing towards the viewer in the middle of the image.

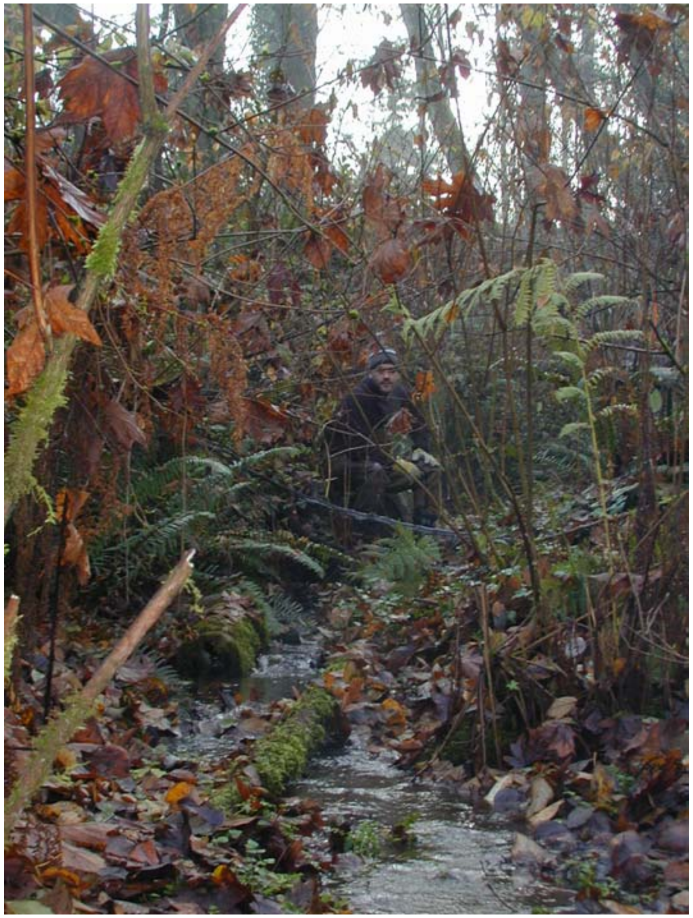


Photo 2. Typical segment of the East Fork of Mapes Creek, Reach 8. Note the low flows and proximity of vegetation to the wetted width.

Photo 3. Wetland at the base of the West Fork Mapes Creek, Reach 7.

Photo 4. Confluence of Duck Pond Tributary with Mapes Creek, Reach 6

Photo 5. Kubota Gardens pond system.

Photo 6. Artificial channel between ponds in Kubota Gardens.

Photo 7. Headwater spring that feeds Koi ponds.

Photo 8. Outlet of upper Koi pond into lower Koi pond.

Photo 9. Downstream view of sediment pool created by concrete weir # 3, Reach 3.

Photo 10. Concrete weir #2, Reach 3.

Photo 11. Concrete weir # 1, Reach 3.

Photo 12. Mapes Creek, Reach 2.

Photo 13. Mapes Creek, Reach 2.

Photo 14. Downstream view of large sediment pool in Reach 1, wetted width spans entire foreground.

Photo 15. Rock cascade at inlet to Sturtevant/Rainier culvert

Photo 16. Inlet to Sturtevant/Rainier culvert with trash rack.

Photo 17. Cascade at inlet to Sturtevant/Rainier culvert

Photo 18. Outlet of Roxbury Street culvert

Photo 19. Inlet to Roxbury Street culvert

Photo 20. Inlet to Renton Avenue culvert

Photo 21. Upstream view of concrete weir #1

Photo 22. Side view of concrete weir #1

Photo 22. Side view of concrete weir #1

Photo 23. Concrete weir #2

Photo 24. Uppermost drop on concrete weir #2

Photo 25. Concrete weir #3

Photo 26. Concrete weir #4

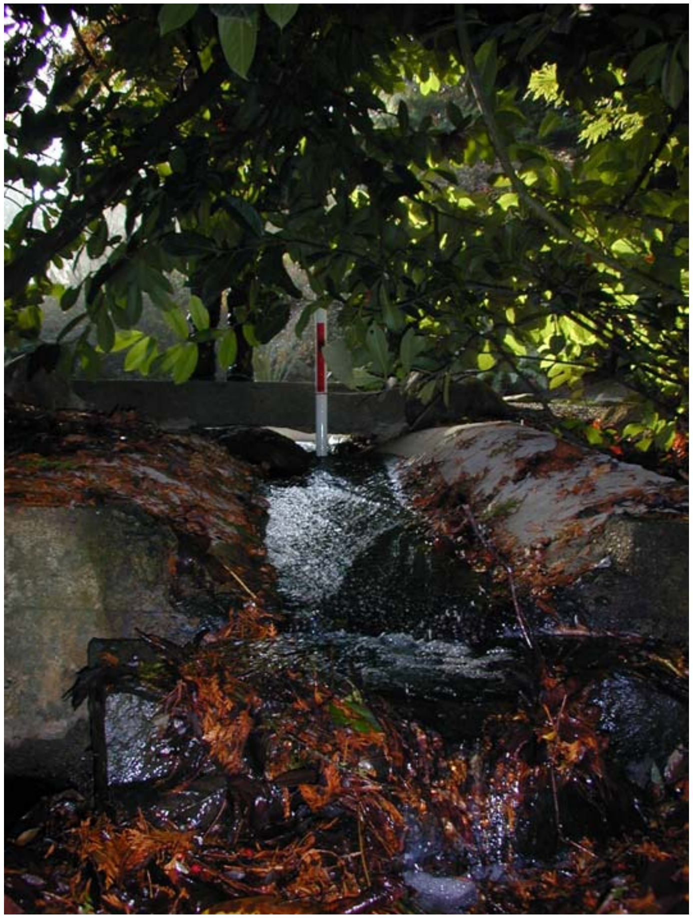


Photo 27. Outflow of pond #1

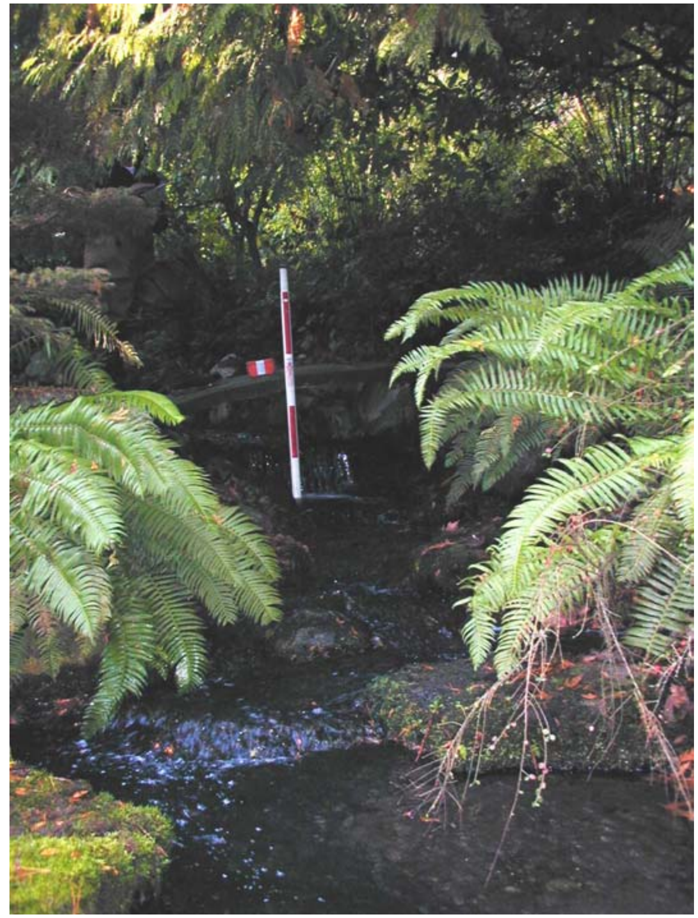


Photo 28. Artificial channel between ponds 1 & 2

Photo 29. Artificial channel between ponds 1 & 2

Photo 30. Artificial channel between ponds 2 & 3

Photo 31. Artificial channel with waterfall between ponds 3 &4

Photo 32. Artificial channel between ponds 4 & 5

Photo 33. Outflow of culvert entering pond #5

STREAM HABITAT REPORT

PUGET CREEK

WRIA # 9

Seattle, Washington

Prepared for:

Seattle Public Utilities
700 5th Avenue
Seattle, Washington 98104

Prepared by:

Cedarock Consultants, Inc.
19609 244th Avenue NE
Woodinville, Washington 98077

February 21, 2014

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDIX

Field Data – Photographs
Field note spreadsheets

1.0 INTRODUCTION

The culvert, headwall, and trash rack associated with the Puget Creek crossing at Puget Way SW are in poor condition and are scheduled for replacement by Seattle Public Utilities (SPU). During the environmental permitting process for this project, the Muckleshoot Indian Tribe (MIT) submitted comments regarding the need to mitigate project impacts related to loss of riparian function, passage of large woody material (LWM), and fish passage. To address these comments, SPU contracted with Cedarock Consultants, Inc. to conduct such background research and field studies as required to assess and inventory stream habitat quality and water type of stream reaches of Puget Creek upstream of the Puget Way SW culvert (Figure 1).

A single 9-inch long resident trout was observed in Trib 60M of Puget Creek (Figure 1) during a survey conducted in the winter of 2006 (Tabor et.al. 2010). The presence of this fish and suitable habitat downstream to the Puget Way SW culvert lead to a conclusion in the Tabor et.al. (2010) report to categorize the channel downstream of Trib 60M as fish-bearing (Type F). Because Puget Creek is intermittent upstream of Trib 60M, flowing only during the wet season, it was categorized as non-fish-bearing (Type Ns).

Field work was completed for this survey during early February 2014. The mainstem of Puget Creek from Puget Way SW upstream to SW Dawson Street (2,800 feet) was walked. Detailed measurements of physical channel characteristics and water quality were collected. Riparian conditions were also evaluated. Portions of two significant tributaries to Puget Creek in this area, and the remainder of the mainstem channel upstream to the headwaters (8,000 feet upstream of Puget Way SW) were also reviewed but in less detail. This is primarily because natural fish passage barriers were located near the mouths of the tributaries, and about 75 feet downstream of SW Dawson Street. No fish were observed during the survey but no formal attempts (e.g. electrofishing) were made.

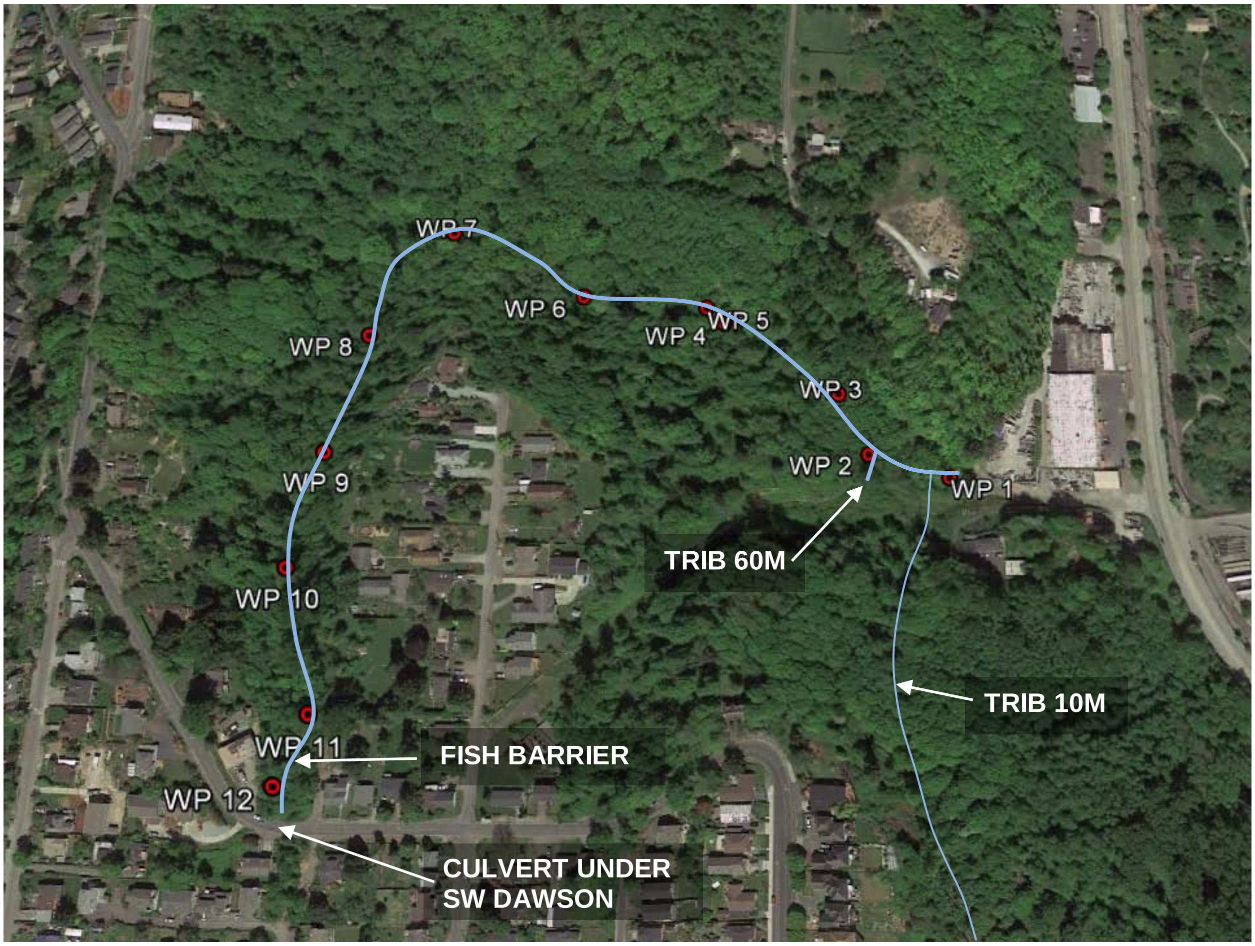


Figure 1. Aerial Photo Showing Puget Creek Survey Reach

2.0 METHODS

Field techniques generally followed guidelines described in Washington Forest Practices Board (WFPB) Manuals (1997 and 2004). These manuals describe both quantitative and qualitative measures for evaluating fish habitat, and reference additional guidelines such as the Timber, Fish, and Wildlife ambient monitoring protocols. Specific techniques utilized for this study are described or referenced below for each habitat feature evaluation technique. Data were recorded on Write-in-the-Rain field sheets and then transferred to Excel spreadsheets which are attached in the appendix.

Puget Creek was walked starting at the culvert under Puget Way SW upstream to SW Dawson Street (2,800 feet). Portions of two tributaries to Puget Creek in this area, and the remainder of the mainstem channel from SW Dawson Street upstream to the headwaters (8,000 feet upstream of Puget Way SW) were also reviewed but in less detail. The detailed survey on the mainstem was ended when a natural and permanent fish passage barrier was encountered 75 feet downstream of SW Dawson Street. The barrier is within an intermittently flowing stream reach and no permanent water is believed to exist upstream (the area is dry for about 4 to 6 months each year, M. Bonoff, SPU Wetland Biologist, pers. comm. 2014).

Distances were measured with a hip chain. Spot locations such as water type and habitat break points, tributaries, potential enhancement locations, barriers, etc. were identified with GPS waypoints.

Habitat units consist of unique channel types (described below). A number of instream and riparian habitat characteristics were collected within each habitat unit. If an individual unit was unusually long, multiple measurements were collected within the unit and averaged. Measured variables included length, wetted width, maximum water depth, bankfull width and depth, dominant and sub-dominant substrate, presence of spawning substrates suitable for resident trout and anadromous salmonids, percent flatwater within riffles and cascades, pool formative element, pool maximum and control depths, substrate embeddedness of pool tailouts, percent wood cover of pools, large wood counts, dominant riparian vegetation by species, percent shade cover, water temperature, and pH. Photographs were taken every 100m and periodically as needed to illustrate an interesting feature (provided in Appendix). Additional detail is provided below.

Habitat Units

Habitat units were separated based on channel gradient and minimum size. They were denoted as flat (<0.1% slope), pools (topographic low points meeting minimum size and residual depth criteria per WFPB 1997), runs/riffles (0.1%<slope<5%), cascades (step pools with a slope>5%), and potential fish passage barriers (slope>16%). Discrete physical habitat measurements were taken at least once within each habitat unit and every five to ten bankfull widths if the habitat unit length exceeded five times the bankfull width.

Channel Gradient

A channel gradient measurement was taken at the start of the survey and every 300 feet thereafter. Gradient was measured as the vertical elevation change (rise) of the channel bed over the horizontal length of distance for which the elevation change was measured (run). The rise was measured using a hand-held level and a stadia rod with the value observed on the stadia rod subtracted from the previously measured height of the observer's eyes above ground level (Northwest Indian Fisheries Commission 1994). The horizontal run was measured with a metal tape over a distance of between 10 and 25 feet depending on grade.

Wetted Width and Depth

The wetted width was measured once in each habitat unit with a length less than five channel widths in length, and once each 5 to 10 channel widths for longer units. The average width for the longer units was recorded. The maximum and average wetted depth for each habitat unit was measured. An estimate of stream flow rate was made at the beginning and ending of the survey and roughly every 300 feet in the intervening distance.

Bankfull Depth and Width

Bankfull width and depth were measured at the beginning of the survey and every 300 feet thereafter. Bankfull depth was measured as the average vertical distance between the channel bed and the estimated water surface elevation required to completely fill the channel to a point above which water would enter the floodplain or intersect a terrace or hillslope (Pleus and Schuett-Hames 1998). Bankfull width was measured as the lateral extent of the water surface elevation perpendicular to the channel at bankfull depth.

Substrate

Substrate was visually examined throughout each habitat unit and a subjective determination made of the dominant and sub-dominant substrate types. Substrate was separated by size according to general salmonid habitat functionality as follows:

Table 1. Substrate Characteristics Evaluated

Substrate	Code	Size	General Salmonid Function
Fines/Organics	F	Silts, clays, and organics	Low value. Degrades spawning habitat
Sand	S	<bb's	Low value
Gravel	G	bb's to golf balls	Resident trout and coho spawning habitat
Cobble	C	Baseballs to volleyballs	Steelhead and Chinook spawning habitat
Boulder	B	> Basketballs	Forms pools and velocity breaks
Bedrock	R	Solid rock/glacial till	No value

Based on Flosi et.al. 1998.

Spawning habitat availability was based on substrate size and minimum spawning site area (Schuett-Hames and Pleus 1996.) Spawning substrate was considered suitable for resident trout if a patch of substrate dominated by gravel in excess of 1 sq.ft. in area and with a depth greater than three inches is present. Spawning substrate was considered suitable for anadromous salmonids if a patch of substrate dominated by gravel or cobble in excess of 10 sq.ft. in area and with a depth greater than six inches was present. Quality was affected by proportion of fines and sands (embeddedness).

Percent Flatwater

In many watercourses human influence has significantly altered factors that form pool habitat (such as the availability of LWM). In these cases, pools that might have formed in low gradient (flatwater or riffle) areas are generally absent. To assess the amount of stream length where pool formation might be improved in the future, and to identify habitat that otherwise may be used as low gradient (coho and resident trout) rearing habitat, the percent of flatwater within riffles and cascades was estimated.

Pool Habitat

Pools were examined in the most detail because of their importance to fish rearing and spawning habitat. Pools were defined using criteria provided in the fisheries module of WFPB (2004). To be considered a pool, the unit must meet minimum size criteria (measured as total area) and maximum depth (measured as residual pool depth) based on bankfull channel width at the unit. Dominant pool formative element was identified as either wood (log or rootwad), bed or bank scour, boulder, or other (concrete blocks). Substrate embeddedness of the pool tailout was examined to identify potential use as spawning substrate. The substrate was considered embedded if greater than 25 percent of the interstitial spaces were clogged with fine material (Flosi et.al. 1998). Percent wood cover of pools was estimated as the total percentage of wetted pool area overlain by logs or rootwads.

Large Woody Material

Pieces of wood found within the bankfull channel width and greater than 6-feet in length and 4-inches in diameter were counted as large woody material. Notes were taken of any logs that appeared to have been artificially placed in the channel or that were greater than 3-feet in diameter (key pieces). Notes were also taken to describe the general condition of instream wood (age, species, etc.).

Riparian Condition

Riparian condition including dominant shrubs and trees, and shade coverage were evaluated at the start of the survey and approximately every 300 feet thereafter. The 3 to 5 most dominant shrubs and trees nearest the channel were identified. Percent canopy closure was measured using a spherical densiometer and the procedure described in Pleus and Schuett-Hames (1998).

Water Quality

Water temperature and pH were measured at the start of the survey and approximately every 300 feet thereafter. Water temperature as measured with a calibrated thermometer. pH was measured using a Hannah Checker® calibrated pH meter.

Photos

Digital photos looking upstream were taken approximately every 300 feet. Additional photos were taken of unusual or relevant features such as barriers, enhancement opportunities, large areas of bank erosion, unusually good or poor habitat conditions, etc.

Fish Migration Barriers

Upstream fish migration barriers were defined as features exceeding the ability of salmonids to pass in an upstream direction. Salmonid passage ability identification utilized measurements and criteria presented in Powers and Orsborn (1985), Bell (1991), and Johnson and Orsborn (1995).

Fish Presence

No specific attempts were made to capture fish but incidental fish observations were to be recorded. If a fish was observed, extra time would have been spent trying to make a positive identification. A dip net was carried.

3.0 RESULTS

3.1 Puget Creek (Puget Way SW to SW Dawson Street)

3.1.1 Habitat Types

The mainstem reach contained a total of 69 different habitat units over 2,772 feet. Shallow riffle habitat ranging in slope from 2 to 5 percent made up 85 percent of the reach by area (88% by length). Pools comprised 14 percent of the reach and cascades made up only 1 percent. Average water depth during the survey was 0.13 feet (1.5 inches) with an average wetted width of 3.6 feet. Pools were the deepest areas with an average maximum depth of 0.73 feet (9-inches). Residual pool depth was 0.62 feet (7.5 inches).

A total of 34 pools were identified for a pool frequency of 64.8 pools/mile. Logs were the primary formative element with 21 (62%) of the pools associated with one or more pieces of wood. Scour or constriction around boulders created 7 (21%) pools. The remaining 6 pools were formed by rootballs (9%) or by other objects such as concrete blocks, bedrock scour, and culvert spill (9%).

Table 2. Habitat Characteristics by Area

Habitat Type	Number of Units	Percent of Total Area	Average Size (sf)	Average Wetted Width	Average Length
Pool	34	14%	37.5	4.2	8.6
Riffle	33	85%	232.6	3.0	74.3
Cascade	2	1%	45.9	3.1	15.1

3.1.2 Channel Morphology

Wetted width averaged 3.6 feet with an average water depth of 0.13 feet and an average maximum depth of 0.53 feet. Wetted width for pools averaged 4.2 feet, for riffles averaged 3.0

feet, and the cascades averaged 3.1 feet. Maximum depth for pools averaged 0.73 feet with the average pool tailout at 0.11 feet. Bankfull width averaged 6.3 feet (range of 4 to 12 feet) and bankfull depth averaged 1.6 feet (range of 0.8 to 3.2 feet).

3.1.3 Substrate Condition

Gravel was the dominant substrate over 67 percent of the creek (by area) with cobble being dominant over 27 percent. The distribution of gravel didn't change much from beginning to end of the survey but was evenly distributed throughout.

Sub-dominant substrate was more variable. Sand and cobble were the leading sub-dominant substrates covering 33 and 34 percent respectively of the mainstem. Gravel was close behind with 26 percent of the area.

The qualitative evaluation of spawning gravel availability found that 88 percent of the wetted channel area contained some potential resident trout spawning habitat. This number overestimates the actual amount of usable habitat but indicates that gravels suitable for use by resident trout were broadly distributed through the length of the channel. Channel area suitable for use by anadromous salmonids was about half of that at 41 percent. Roughly 12 percent of the channel contained no potential spawning habitat due to poorly sized or absent substrates, or very high embeddedness levels.

Table 3. Substrate Results

Substrate	Dominant Substrate		Sub Dominant Substrate	
	Habitat Units	Channel Area Covered	Habitat Units	Channel Area Covered
Fines	3	3%	5	2%
Sand	5	3%	29	33%
Gravel	49	67%	12	26%
Cobble	11	27%	17	34%
Boulder	1	1%	1	2%
Bedrock	0	0%	5	2%
	69	100%	69	100%

3.1.4 Large Woody Material

A total of 129 pieces of LWM were counted. Virtually all of the pieces consisted of hardwood (cottonwood and alder) stems and branches ranching between 4-inches and about 16-inches in diameter. All wood appears to have been contributed by the local riparian area (no downstream transport or mitigation projects), and in particular where recent slides have toppled trees. A number of additional pieces were observed on the banks ready to be recruited if local bank failures occur. The future supply of trees near the creek is moderate but consists almost entirely of additional hardwoods. A few young (10-15 foot tall) conifers were noted in places.

3.1.5 Fish Migration

A single natural fish migration barrier was found on the mainstem of Puget Creek (Figure 14). It is located 2,690 feet upstream of Puget Way SW and about 75 feet downstream of SW Dawson Street. The barrier consists of two contiguous parts: a 3.5 to 4-foot high bedrock (till) outcropping with a 100% slope, followed immediately by a 4-foot high 33 percent grade cascade. There are no pools at the base or intervening steps from which fish could launch to move up the obstruction. This area of Puget Creek, and the reach upstream to the headwater reportedly goes dry during the typical summer for up to 4 months (Tabor et.al. 2010, Bonoff 2014).

The ability of fish to move upstream from Puget Way SW to the fish migration barrier is relatively unencumbered as long as sufficient flow is present. The channel slope is moderate but consistent with only a few steep areas, or minor steps that might partially or temporarily hamper fish from moving upstream. None of the intervening obstacles were absolute or permanent migration barriers.

The largest single impediment to fish distribution in Puget Creek is the seasonal lack of flow upstream of Trib 60M.

With the exception of the lower 45 feet of Trib 60M (Figure 4), no tributaries containing usable fish habitat were found. A natural migration barrier exists on Trib 10M near the confluence, however, the barrier may be man-influenced. It was difficult to survey under the dense blackberry, and the lack of habitat upstream made positive identification irrelevant.

3.1.6 Riparian Function

The mainstem contains excellent riparian shading. A total of 9 canopy closure measurements found an average closure of 95 percent with a range between 79 and 99 percent. Most of the canopy was provided by mature deciduous trees with moderately dense underlying riparian shrubs in some areas.

Big leaf maple trees are the most common of the shrub and trees species present showing up in 100 percent of the vegetation survey plots. Sword fern was second (75%) and red alder was third (63%). Various other native species (salmonberry, cottonwood, Indian plum, elderberry, cedar and hazelnut) were all observed at between 13 and 50 percent of the survey sites. Non-native species included Himalayan blackberry (13%), English ivy (25%), and English holly (25%).

No large conifers were observed anywhere. Roughly half a dozen young conifer to 10 to 15-feet tall were noted in the upper basin. The near-term potential for recruitment of these trees is low.

3.1.7 Water Quality

Ambient air temperature during the survey date was very cold at about -4 C^o (25 ^oF). Water flow was estimated at 0.2 cfs at the start of the survey and 0.05 cfs near the end. Inflow from Trib 60M was estimated at 0.1 cfs. Nearly a dozen small tributaries and seeps were observed during the survey and likely accounted for the rest of the inflow.

Water temperature was measured eight times during the survey with an average of 1.4 ^oC and a range between 1 ^oC and 3 ^oC. The warmest temperature was noted just downstream of Trib 60M and likely reflected a slight warming associated with the ground contact within the long culvert. pH was measured seven times during the survey with an average of 7.32 and a range between 7.09 and 7.49.

3.2 Puget Creek (SW Dawson Street to Headwaters)

This reach is upstream of a natural fish migration barrier and reportedly flows only intermittently with a long (2 to 4 month) dry period during the typical summer. The channel was spot checked to evaluate functional benefit to habitat downstream.

Puget Creek in this area consists of a roughly 5,000 foot long, relatively straight and very low gradient channel (Figure 16). With a few exceptions, the channel is open and mostly unconstrained. Habitat is dominated by flatwater and pools. Large wood loading is moderate and the potential for future recruitment is good with roughly 150-foot wide vegetated buffers along both banks. Despite being relatively straight, the channel has some complexity due to wood loading and a variable width.

Upper Puget Creek likely provides a good source of beneficial nutrients and organic material to fish-bearing reaches downstream. It is not a source of large wood because of the gradient and intervening culverts.

3.3 10M Tributary

This tributary enters the mainstem from the south approximately 30 feet upstream of the culvert under Puget Way SW. The tributary drains a small valley east of and parallel to 16^{th} Avenue SW. A small stream ranging between 6-inches and 2-feet wide, in a channel between 2 to 4 feet wide (bankfull) drains the valley. The stream had an average depth of less than an inch with a maximum depth of 0.2 feet based on a quick survey of several hundred feet. A single slope measurement over 15 feet found a grade of 21.7 percent. Substrate was dominated by cobble heavily embedded with sand and silts. Steep banks consisting of unstable blue/grey clay contribute large amounts of very fine sediments. Small patches of gravel were underlain by deep silts resulting in no usable spawning habitat. No pools or large woody material were observed.

The creek dissipates over a broad floodplain before it reaches Puget Creek. The area is covered with dense Himalayan blackberry and was difficult to survey in depth. However, it does not appear to be fish-passable. Flow collects in what appears to be an old roadside ditch and then passes through a culvert before discharging into a narrow channel 20-feet from the mainstem. The culvert is perched approximately 18-inches above the channel and is likely impassable.

This tributary was not studied in depth for two reasons: 1) there appears to be a natural (though possibly man-influenced and temporary) fish passage barrier where flow sheet flows across a broad floodplain reach adjacent to Puget Creek; and 2) the channel upstream of the floodplain has little to no habitat based on small size, intermittent flows, and high gradient.

3.4 60M Tributary

This major tributary enters the mainstem from the south approximately 200 feet upstream of the culvert under Puget Way SW. The tributary drains stormwater and groundwater from the 17th Avenue SW area on the upper plateau. The tightlined stormwater drainage system along 17th Avenue SW enters a mainline pipe at the top of the hill near Dawson Street and is then piped approximately 1,100 feet down the 18 to 25% slope to a discharge point about 50-feet south of the mainstem of Puget Creek. A roadside ditch along this alignment collects ground and surface water on the slope and delivers it via a separate pipe to the same discharge location. 50-feet of open channel downstream of the culvert outlets contains good quality habitat with a nice mix of pools and riffle. It is this area where a 9-inch rainbow trout was found in 2006 (Tabor et.al. 2010).

Flow from this drainage contributed about half of the water in the mainstem downstream of the confluence when surveyed in February for this project. Tabor et.al. (2010) reported that the tributary provided nearly all of the flow during a summer visit and “most of the streamflow in Puget Creek” during a February 2006 site visit. Tabor et.al. (2010) reported that the mainstem upstream of the confluence flowed only intermittently in places before drying up completely a short distance upstream.

4.0 DISCUSSION

Fish habitat quality in the surveyed mainstem reach of Puget Creek upstream to SW Dawson Street is evaluated using criteria from Best Available Science references applicable to Washington State salmonids (e.g. NMFS 1996, WFPB (1997), and Ecology 2002). Current condition of key habitat forming elements and pathways are described below and summarized in Table 4. Fish rearing and spawning habitat conditions are also described with a summary provided in Table 5.

Table 4. Current Condition of Key Habitat Forming Elements and Pathways

Habitat Function	Existing Conditions	Condition Rating
Water Quality		
Temperature	Not Evaluated	*Not Evaluated*
pH	Average 7.32 (7.09 – 7.49)	**Properly Functioning**
Habitat Access	No manmade blockages between Puget Way SW and natural barrier, or to potentially fish-bearing tributaries.	**Properly Functioning** (in area surveyed)
Habitat Elements		
Substrate	Dominated by gravel but with high sand/silt embeddedness in many locations	**At risk**
Large Woody Material	Low LWM counts at 0.29 pieces per channel width (Good = 2 per channel width)	**Not properly functioning**
Pool Frequency	64 pools per mile which is less than the recommended frequency of 160/mile	**Not properly functioning**
Pool Quality	No deep pools; very little cover	**Not properly functioning**
Off-Channel Habitat	Highly constrained channel with no off-channel habitat.	**Not properly functioning**
Refugia	Small shallow pools, low LWM counts, and no off-channel habitat	**Not properly functioning**
Channel Condition and Dynamics	Excessive sediment inputs, reduced LWM inputs, channelization	**Not properly functioning**

4.1 Water Quality

We were not able to evaluate peak temperatures during this study due to survey timing limitations. However, we did observe that the very low temperatures encountered during this survey, in combination with low flows, resulted in significant freezing throughout the water column. While flow was still moving in most places, overall habitat availability was likely reduced by the presence of relatively thick ice.

Questions have been raised about the quality of water in Puget Creek as result of past dumping of large amounts of cement kiln dust in the immediate area of the lower channel. Because of the potential effect of concrete on pH, we collected pH measurements approximately every 300 feet. The results showed normal pH values (average of 7.32) with no potential for adverse effects on fish. Adverse effects can occur if the values are outside the range of 6.5 to 8.5 (WAC-173-201A-200 (1)(g)).

Table 5. Current Condition of Salmonid Habitat

Habitat Function	Existing Conditions
Summer Rearing	Low quality to none based on long dry reaches, low pool frequencies, poor pool quality, and very shallow water depths.
Winter Rearing	Moderate to low quality based on low pool frequencies, poor pool quality, low LWM counts, high embeddedness, and absence of off-channel and refuge habitat.
Spawning Habitat	Moderate quality with relatively high availability for resident trout. Limited by high silts and sand abundance in some areas. Good quality areas are primarily in the lower reaches and are best suited to resident trout and smaller salmon (coho).
Migration	Fish movement between Puget Way SW and a natural migration barrier 75 feet downstream of SW Dawson Street appears to be relatively unobstructed most of the year. Dry reaches during the summer and other low flow periods limit fish to the lower few hundred feet of the channel.

4.2 Habitat Access

Habitat access is considered to be properly functioning when no man-made barriers are present that inhibit upstream or downstream fish passage. No manmade barriers were observed in the reach of Puget Creek upstream of Puget Way SW. Habitat access upstream of Puget Way SW would be considered properly functioning.

4.3 Habitat Elements

4.3.1 Substrate

Substrate is considered to be properly functioning when it is dominated by gravel and cobble with low embeddedness. Puget Creek in the survey reach is fairly responsive to sediment supply/discharge because of the moderate gradient. Gravel is the dominant substrate throughout this reach with long pool/riffle complexes where both trout and salmonids preferring smaller substrate sizes might be expected to spawn. A high level of sand and silt in some localized areas results in a relatively high embeddedness, especially near areas of ongoing bank instability. The level of embeddedness reduces spawning habitat quality in these areas and these sections would be considered at risk or not properly functioning. Overall the level of embeddedness is low and habitat quality is relatively good. Substrate quality would be considered good but at risk due to the large supply of very fine materials stored in the banks.

4.3.2 Large Woody Material

LWM frequency was measured at 0.29 pieces/channel width where greater than 2.0 pieces/channel width is considered to be good, and less than 1.0 pieces/channel width is considered poor. Woody material was dominated by hardwoods which have a shorter lifespan that the more desirable fir and cedar. The wood was also relatively small with no key pieces. Large woody frequency is considered not properly functioning due to the low count, small size, and absence of fir and cedar.

4.3.3 Pool Frequency

Pool frequency is considered to be properly functioning for a channel of this size when pools are observed at a rate of approximately 160 per mile. Puget Creek within the survey reach contains 34 pools over 2,772 feet for a frequency of 64 pools per mile. This is considered not properly functioning for pool frequency. Pool formation in the reach is strongly affected by the moderate gradient (average 6%), abundant gravel (gravel was dominant or sub-dominant in 93% of the reach), and lack of large woody material. The absence of downed trees and other large wood pieces likely have a significant effect on pool frequency. Pool frequency is considered not properly functioning due to the low count.

4.3.4 Pool Quality

Pool quality is considered to be properly functioning when the pools are greater than 3 feet deep, contain cold water, and have good cover (woody material or large boulders). No pools greater than 3-feet were found and percent cover averages only 3 percent. Pool quality would be considered very poor and not properly functioning.

4.3.5 Off-Channel Habitat

Off-channel habitat is used by fish to escape high winter flows and by some species for both summer and winter rearing. Off-channel habitat quality is considered to be good when backwaters are present in places and they contain good cover and complexity. No off-channel habitat or backwaters were observed. This is not unusual for constrained moderate gradient stream reaches such as the portion of Puget Creek that was surveyed. However, significant channel down-cutting due potentially to higher than normal peak flows and very low LWM loading may contribute to a lack of side channels. Off-channel habitat is considered not properly functioning due to a complete absence of this characteristic.

4.3.6 Refugia

Refugia provides habitat where fish can go during unusual events. This could be thermal refugia during warm periods, deeper pools during low flow periods, and off-channel area or large boulders during large flood events. Refuge habitat helps preserve populations or sub-populations during catastrophic events. Refuge habitat is considered to be properly functioning when it is present, and sufficient in size, quality, and connectivity. The metric is relatively subjective.

Low pool counts, very shallow pools, no off-channel habitat, and the lack of LWM limits potential refugia in this channel. Refugia availability would be considered not properly functioning in Puget Creek.

4.4 Channel Condition and Dynamics

Channel condition is considered to be properly functioning when the channel form is unconstrained by anthropogenic features and free to develop naturally, but without evidence of unusually high rates of channel change that might be due to frequent flooding, excessive sediment supply, or lack of riparian buffer stabilization.

The Puget Creek channel has been heavily influenced by human activity in the watershed including excessive sediment inputs, reduced LWM inputs, changes in water quantities and flow rates, channelization, riparian buffer width and composition changes, and stream crossings. Many of these changes currently influence channel function and fish habitat. Significant unmitigated development of the headwaters in particular has greatly altered flow rates and sediment delivery. Past logging and fill placement within the survey reach has also modified the channel in some areas. Channel condition and dynamics would be considered not properly functioning in Puget Creek.

4.5 Summer Rearing

Summer rearing in the survey reach and upstream is limited by long dry spells, low pool frequencies, poor pool quality, and very shallow water depths. Good potential summer rearing quality exists in the lowest 200-300 feet where flows are perennial and the potential for good pool development is highest. Overall, summer rearing habitat is currently considered to be both low in quantity and quality.

4.6 Winter Rearing

Winter rearing is limited by low pool frequencies, poor pool quality, low LWM counts, high embeddedness, and absence of off-channel and refuge habitat. Unusually high peak flows and unstable channel conditions may also be significant factors limiting winter habitat. Overall, winter rearing habitat is currently considered to be both low in quantity and quality.

4.7 Spawning and Incubation

Spawning and incubation habitat quality is of moderate quality due to the abundant gravel supply, long riffles, and numerous pool tailouts. Spawning habitat quality is somewhat limited by shallow depths and high fine sediment concentrations in some areas. Unstable channel conditions and scouring flows may also be adverse issues. Good quality areas are primarily in the lower reaches and are best suited to resident trout and the smaller species of salmon like coho.

4.8 Mitigation Opportunities

Potential mitigation opportunities noted during the habitat survey are listed here. The list is not comprehensive, nor have any of the options received any level of detailed consideration. The list is provided solely as a starting point for further consideration.

- The 200 feet of channel upstream of the Puget Way SW culvert to the Trib 60M confluence is a low gradient area with permanent flow and a deformable gravel substrate that could benefit from the addition of large woody material. Additional pool habitat could be created leading to enhanced summer and winter rearing habitat.
- The next 100 or so feet upstream of Trib 60M is similar in nature but with significantly less average flow. Winter rearing habitat and spawning habitat could potentially be enhanced in this area with the addition of LWM.
- The riparian buffer south of the lowermost 200 feet of channel is highly degraded by the presence of exotic plant species, primarily Himalayan blackberry. While plant selection is probably limited by the powerlines overhead, some benefit in the form nutrient contribution could be achieved by clearing and controlling non-natives and enhancing with native shrubs.
- Conifers are significantly lacking throughout the basin and threaten future LWM supplies. Underplanting with tree species that can handle understory conditions (e.g. hemlock) would create a long term benefit to LWM loading and concomitant habitat attributes.
- Exotic species, primarily English ivy, Himalayan blackberry, English holly, Japanese knotweed, and an unidentified shrub are creeping into the basin and threatening the relatively good riparian buffer. Management actions focused on these invasive species could help promote native plant growth in the area.

4.9 Water Typing

The mainstem of Puget Creek between Puget Way SW and a natural, permanent fish barrier located at a point 2,690 feet upstream (Lat 47.5562; Lon -122.3584) meets all WAC 222-16-030 criteria to be classified as a Type F Water. This is based on quantitative data showing an average channel gradient of 6 percent with no permanent fish obstructions, a continuous channel width in excess of 6 feet, and habitat types that would provide usable fish habitat on a seasonal basis.

Puget Creek upstream of the fish barrier to the headwaters should be classified as a Type Ns Water. This reach is a natural, seasonal, non-fish habitat stream in which surface flow is not present for at least some portion of a year of normal rainfall and is not located downstream from any stream reach that is a Type Np Water.

Trib 10M is a natural watercourse that probably does not meet minimum physical characteristics to be presumed fish-bearing. Spots surveys found gradients approaching and exceeding 20 percent, channel widths less than 3-feet, almost no usable fish habitat, very little water during the winter (Figure 17), and what is believed to be natural fish-passage obstructions near the confluence with Puget Creek (Figure 18). Because fish cannot currently reach Trib 10M, detailed studies needed to verify water type were not completed.

Trib 60M from the Puget Creek confluence upstream approximately 50 feet to the discharge culvert should be classified as a Type F Water. This is based on having the same general channel measurements as Puget Creek with no fish passage obstructions between the channel and Type F Waters. From all reports there are no natural waters upstream of this point.

5.0 REFERENCES

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APPENDIX

FIELD DATA

Photographs
Field Note Spreadsheets

Figure 2. Puget Creek (0m – WP 1)

Figure 3. Puget Creek (22m)

Figure 4. Trib 60M (WP 2)

Figure 5. Puget Creek (100m – WP 3)

Figure 6. Puget Creek (200m – WP 4)

Figure 7. Puget Creek (300m – WP 6)

Figure 8. Puget Creek (400m – WP 7)

Figure 9. Puget Creek (500m – WP 8)

Figure 10. Puget Creek (600m – WP 9)

Figure 11. Puget Creek (700m – WP 10)

Figure 12. Puget Creek (780m)

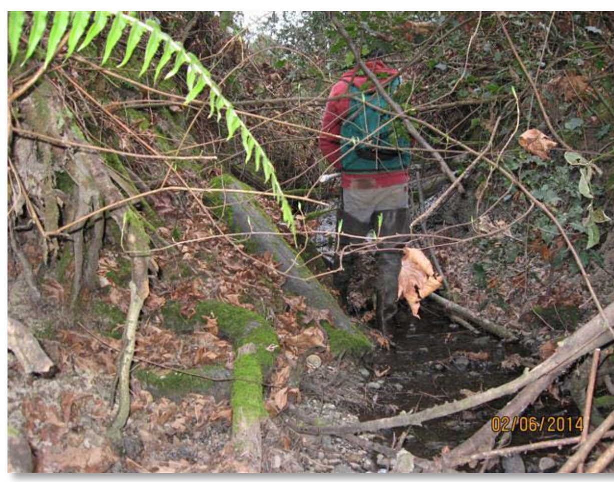

Figure 13. Puget Creek (800m – WP 11)

Figure 14. Puget Creek (820m – Barrier)

Figure 15. Puget Creek (845m – WP 12)

Figure 16. Puget Creek south of Dawson

Figure 17. Trib 10M alluvial fan

Figure 18. Trib 10M - typical habitat

Figure 19. Trib 10M – outfall to Puget Creek

Puget Creek - Stream Habitat Survey

2/16/2014

Total length of Puget Creek = 2441 m (8000 ft or 1.51 miles)
Natural fish barrier at 820m (2690 ft or 0.51 miles)

Reach 1 - Puget Way to SW Dawson Street

Measurements

Measured distance (m)	0	6.8	9.1	28.5	33.1	48.8	49.4	103	105.8	123.5	127	144.7	147.3	151.3
Actual Distance (m)	0	6.8	9.1	28.5	33.1	48.8	49.4	103	105.8	123.5	127	144.7	147.3	151.3
Actual Distance (ft)	0	22	30	93	109	160	162	338	347	405	417	475	483	496
Habitat Unit Length (ft)	22	8	64	15	51	2	176	9	58	11	58	9	13	4
GPS Waypoint #	1						2, 3							
Slope	4.2%						3.0%							
Unit Type	R	P	R	P	R	P	R	P	R	P	R	P	R	P
Dominant Substrate	G	G	G	G	G	G	G	G	G	G	G	G	C	G
Subdominant Substrate	C	C	C	S	C	R	C	S	C	S	C	S	G	S
% pool/flatwater	10		20		20		10		10		15		0	
Wetted width (ft)	3.0	4.5	4.0	4.0	3.0	2.5	3.0	4.1	4.0	3.0	2.6	2.9	2.2	4.0
Pool form		L		L		O		L		O		L		L
% wood cover		0		0		0		0		0		0		30
Pool Tail embedded?		N		N		N		Y		Y		Y		N
Spawning Gravel?	AR	AR	AR	AR	AR	R	AR	N	AR	N	AR	R	AR	R
Pool Tail Crest Depth (ft)		0.10		0.10		0.15		0.15		0.10		0.10		0.10
Average Depth (ft)	0.10		0.15		0.15		0.15		0.15		0.10		0.15	
Max Depth (ft)	0.20	0.80	0.60	0.70	0.40	0.90	0.40	0.50	0.50	0.50	0.40	0.60	0.40	0.90
Shade (%)	79						99							
Bankfull Width (ft)	7.5	7.5	6.7	5.5	5.5	5.6	6.5	7.5	5.5	5.3	5.7	7.6	8.0	8.0
Bankfull Depth (ft)	3.2	3.2	2.5	2.2	2.3	2.3	1.7	1.7	1.7	2.5	1.5	1.5	1.2	1.2
LWD Counts	0	0	0	2	0	0	0	1	1	0	5	2	0	1
Photos	1, 2		3	4	5		6		7		8			
Time	9:27 AM						10:35 AM							
Temperature oC	3						1.0							
Flow (cfs)	0.20						0.10							
pH	7.48						7.49							
Note #	1		2		3		4	5	6		7			

Notes

1 - Air Temp - 25C; Big leaf maple, Himalayan blackberry
2 - Major trib at 10m (Puget Ridge Cr.) RB. 5 gpm. 20-feet up 5% slope to 24" culvert perched 18" above channel.   (calculated avg 17.7% slope)
3 - Good enhancement potential (Photo 5). Downstream of major trib at 60m
4 - Major trib (from culvert) at 60m RB. 50% of total flow.
5 - 100m: Alder, big leaf maple (BLM), sword fern, Indian plum (IP)
6 - Photo at 122m of steep bank on right
7 - Photo bank failure 138m.
8 - Seep LB 1 gpm 173.5m
9 - 200m BLM, Alder, salmonberry, sword fern hazelnut.
10 - minor trib RB 229m. Fine picking up considerably due to LB slides.
11 - 300m hazelnut, elderberry, 3 conifer, BLM, swordfern. Photo 12 322m. Tiny trib LB 370m
12 - trib LB 1 gpm 396m. 400m BLM cedar, IP, SB, Alder. 408m trib LB 1 gpm
13 - 500m
14 - 600m Photo 16 alder, swordfern, BLM, SB
15 - 700m Photo 17 BLM, alder, cottonwood, swordfern, English ivy, IP
16 - 800m BLM, cottonwood, English holly, swordfern, IP. Photos 20-21 of 3.5-4 ft high bedrock slope, no jump pool @820m 1.8'/12' (33%) slope above BARRIER
17 - Pool at base of culvert. Photo 22 Culvert at slope, probably not fish passable.

Puget Creek - Stream
2/16/2014

Reach 1 - Puget Way to

Measurements

Measured distance (m)	152.6	158.1	161.5	162.6	165	173.3	174.8	185.7	190.8	220.7	225.7	232.2	235.6	238.2
Actual Distance (m)	152.6	158.1	161.5	162.6	165	173.3	174.8	185.7	190.8	220.7	225.7	232.2	235.6	238.2
Actual Distance (ft)	501	519	530	533	541	568	573	609	626	724	740	762	773	781
Habitat Unit Length (ft)	18	11	4	8	27	5	36	17	98	16	21	11	9	10
GPS Waypoint #									4					
Slope									2.2%					
Unit Type	R	P	R	P	R	P	R	P	R	P	R	P	R	P
Dominant Substrate	G	G	C	G	G	G	G	G	G	G	G	G	G	S
Subdominant Substrate	C	S	G	S	S	S	S	S	C	R	C	S	S	F
% pool/flatwater	10		0		5		10		20		5		5	
Wetted width (ft)	2.5	3.0	2.5	3.2	2.0	2.9	2.0	3.5	2.0	3.5	2.5	2.5	3.0	2.7
Pool form		L		L		L		L		L		L		L
% wood cover		10		0		0		0		5		5		0
Pool Tail embedded?		Y		Y		Y		Y		Y		Y		Y
Spawning Gravel?	AR	R	N	N	R	R	AR	R	AR	R	AR	N	AR	N
Pool Tail Crest Depth (ft)		0.10		0.10		0.1		0.10		0.10		0.15		0.10
Average Depth (ft)	0.20		0.10		0.15		0.15		0.10		0.10		0.10	
Max Depth (ft)	0.30	0.50	0.10	0.50	0.30	0.50	0.40	0.90	0.40	0.60	0.40	0.70	0.40	0.70
Shade (%)									98					
Bankfull Width (ft)	5.0	5.5	4.5	4.9	4.0	4.1	5.0	5.0	4.5	6.0	5.0	8.0	6.0	9.5
Bankfull Depth (ft)	1.2	1.2	1.2	1.4	1.2	1.1	1.2	2.0	1.5	1.5	1.5	2.0	3.0	1.9
LWD Counts	2	3	1	2	1	2	2	1	1	1	4	5	1	2
Photos									9			10		
Time									11:30 AM					
Temperature oC									1.0					
Flow (cfs)									0.10					
pH									7.24					
Note #						8			9					10

Notes

Puget Creek - Stream
2/16/2014

Reach 1 - Puget Way to

<u>Measurements</u>

Measured distance (m)	241.2	245.5	248	262.8	265.2	288.1	289.8	394.8	397.1	413.1	415.4	431.4	434.2	441.4
Actual Distance (m)	241.2	245.5	248	262.8	265.2	288.1	289.8	394.8	397.1	413.1	415.4	431.4	434.2	441.4
Actual Distance (ft)	791	805	813	862	870	945	951	1295	1302	1355	1363	1415	1424	1448
Habitat Unit Length (ft)	14	8	49	8	75	6	344	8	52	8	52	9	24	6
GPS Waypoint #							6		7					
Slope							2.6%		6.2%					
Unit Type	R	P	R	P	R	P	R	P	R	P	R	P	R	P
Dominant Substrate	S	G	G	G	G	G	G	G	G	G	C	G	C	C
Subdominant Substrate	F	S	C	F	S	F	C	C	C	S	G	S	G	G
% pool/flatwater	5		5		5		5		5					
Wetted width (ft)	2.0	3.0	2.0	5.0	3.6	5.0	2.7	4.0	4.2	5.0	4.0	6.5	2.5	4.5
Pool form		L		L		R		L		L		L		B
% wood cover		5		5		2		5		0		0		0
Pool Tail embedded?		Y		N		Y		Y		Y		Y		Y
Spawning Gravel?	N	N	R	R	AR	R	AR	R	AR	R	AR	R	R	R
Pool Tail Crest Depth (ft)		0.1		0.1		0.1		0.1		0.25		0.1		0.1
Average Depth (ft)	0.10		0.10		0.15		0.10		0.15		0.10		0.10	
Max Depth (ft)	0.20	0.50	0.15	1.50	0.30	0.70	0.35	0.90	0.30	0.70	0.30	0.70	0.20	0.50
Shade (%)							88		97					
Bankfull Width (ft)	9.1	5.9	7.0	8.0	5.0	6.5	7.0	5.0	6.5	7.6	7.0	7.0	7.5	6.5
Bankfull Depth (ft)	1.5	1.4	1.2	2.0	1.5	1.7	1.4	1.5	1.0	1.5	1.6	1.5	1.0	1.4
LWD Counts	0	1	2	1	0	2	7	2	1	1	0	1	1	0
Photos							11, 12		13					
Time							12:35 PM		1:14 PM					
Temperature oC							1.0		1.0					
Flow (cfs)							0.10		0.10					
pH							7.41		7.09					
Note #							11		12					

<u>Notes</u>

Puget Creek - Stream
2/16/2014

Reach 1 - Puget Way to

Measurements

Measured distance (m)	443.1	460.2	461.7	500.3	502	520.4	521.3	529.9	532.4	632.3	633.6	638.8	646.5	647.9
Actual Distance (m)	443.1	460.2	461.7	500.3	502	520.4	521.3	529.9	532.4	632.3	633.6	638.8	646.5	647.9
Actual Distance (ft)	1453	1509	1514	1641	1647	1707	1710	1738	1746	2074	2078	2095	2121	2125
Habitat Unit Length (ft)	56	5	127	6	60	3	28	8	328	4	17	25	5	179
GPS Waypoint #			8						9					
Slope				12.6%					5.8%		18.4%			
Unit Type	R	P	R	P	R	P	R	P	R	P	C	R	P	R
Dominant Substrate	C	G	C	S	C	G	C	G	C	C	B	G	G	G
Subdominant Substrate	B	R	G	G	G	C	G	S	G	G	C	R	S	S
% pool/flatwater														
Wetted width (ft)	4.0	4.6	3.0	3.0	4.0	4.5	3.0	3.8	3.5	3.1	3.0	3.0	2.6	3.5
Pool form		B		L		L		B		B			B	
% wood cover		0		10		5		0		0			0	
Pool Tail embedded?		Y		Y		Y		Y		Y			Y	
Spawning Gravel?	N	N	R	N	R	R	R	R	R	N	N	N	N	R
Pool Tail Crest Depth (ft)		0.1		0.1		0.1		0.1		0.1			0.1	
Average Depth (ft)	0.10		0.10		0.10		0.10		0.10		0.20	0.10		0.10
Max Depth (ft)	0.20	0.50	0.40	0.70	0.20	0.60	0.20	0.60	0.40	0.70	0.40	0.40	0.60	0.40
Shade (%)			98						98					
Bankfull Width (ft)	7.0	7.7	6.0	8.0	5.5	6.0	6.0	6.0	7.2	6.0	4.5	6.2	6.2	8.0
Bankfull Depth (ft)	1.0	1.8	1.1	1.5	0.9	1.3	0.9	1.5	1.1	1.2	1.8	1.1	1.4	0.9
LWD Counts	0	0	3	1	4	2	1	0	19	0	2	9	1	13
Photos			14					15		16				
Time			1:48 PM						2:19 PM					
Temperature oC			1.0						1.0					
Flow (cfs)			0.05						0.05					
pH									7.37					
Note #			13						14					

Notes

Puget Creek - Stream

2/16/2014

820
2690

Reach 1 - Puget Way to

Measurements														END
Measured distance (m)	702.5	705.1	714	718	722.8	726.4	738.8	741.7	758.1	759.9	792.4	794.3	840.4	845
Actual Distance (m)	702.5	705.1	714	718	722.8	726.4	738.8	741.7	758.1	759.9	792.4	794.3	840.4	845
Actual Distance (ft)	2304	2313	2342	2355	2371	2383	2423	2433	2487	2492	2599	2605	2757	2772
Habitat Unit Length (ft)	9	29	13	16	12	41	10	54	6	107	6	151	15	
GPS Waypoint #	10											11	12	
Slope	3.8%											2.9%		
Unit Type	P	R	C	P	P	R	P	R	P	R	P	R	P	
Dominant Substrate	G	S	G	F	G	G	S	G	G	G	F	G	F	
Subdominant Substrate	C	G	S	S	S	S	F	S	S	S	R	S	S	
% pool/flatwater			0			50		10		15				
Wetted width (ft)	6.7	3.5	3.1	4.0	4.5	3.0	5.9	3.0	4.5	3.5	4.5	3.0	12.0	
Pool form	B			L	L		R		R		B		O	
% wood cover	0			0	5		10		0		0		0	
Pool Tail embedded?	Y			Y	Y		Y		Y		Y		Y	
Spawning Gravel?	R	R	N	N	N	R	N	AR	N	R	N	R	N	
Pool Tail Crest Depth (ft)	0.1			0.1	0.1		0.1		0.05		0.1		0.1	
Average Depth (ft)		0.15	0.20			0.20		0.10		0.10		0.10		
Max Depth (ft)	1.00	0.30	0.40	1.10	0.90	0.40	0.60	0.30	0.60	0.40	0.80	0.40	1.30	
Shade (%)	97												99	
Bankfull Width (ft)	7.5	6.0	10.0	4.5	5.5	4.0	6.0	6.0	5.0	5.5	5.5	5.0	12.0	
Bankfull Depth (ft)	2.0	1.3	1.3	2.5	1.7	1.0	1.3	1.0	1.3	0.8	1.7	1.3	3.1	
LWD Counts	0	0	0	1	1	1	1	3	0	7	0	1	0	
Photos	17						18					19-21	22	
Time	2:58 PM											3:38 PM		
Temperature oC												2.0		
Flow (cfs)												0.05		
pH												7.15		
Note #	15											16		

Notes

Puget Creek - Stream
2/16/2014

Reach 1 - Puget Way to

Measurements	Average	Total	Max	Min	Count
Measured distance (m)					
Actual Distance (m)					
Actual Distance (ft)					
Habitat Unit Length (ft)					
GPS Waypoint #					
Slope	6.17%		18.4%	2.2%	
Unit Type					69
Dominant Substrate					
Subdominant Substrate					
% pool/flatwater	10.4		50.0	0.0	
Wetted width (ft)	3.6		12.0	2.0	
Pool form					
% wood cover	3		30.0	0.0	34
Pool Tail embedded?					
Spawning Gravel?					
Pool Tail Crest Depth (ft)					
Average Depth (ft)	0.13		0.20	0.10	
Max Depth (ft)	0.53		1.50	0.10	
Shade (%)	94.8		99	79	9
Bankfull Width (ft)	6.3		12.0	4.0	
Bankfull Depth (ft)	1.6		3.2	0.8	
LWD Counts		129	19	0	
Photos					
Time					
Temperature oC	1.4		3.0	1.0	8
Flow (cfs)	0.09		0.20	0.05	8
pH	7.32		7.49	7.09	7
Note #					

Notes